HUMAN PESTICIDE EXPOSURE ASSESSMENT

NALED

(An Organophosphate Insecticide for a Variety of Agricultural and Non-Agricultural Uses)

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ABSTRACT

This second revision updates the list of naled products currently registered in California, revises the dermal absorption rate used in the exposure assessment, and adds a list of the unabsorbed dermal doses (in µg/cm^2) to account for the localized skin effects considered in the risk characterization document (RCD). This exposure assessment is written to be an integral part of the Department's RCD prepared for naled, which is an organophosphate used for control of a great variety of insects and mites. A total of 15 naled products are registered in California, with over 70% of the total (reported) annual usage being on cotton, fruits, nuts, vegetables, and other agricultural commodities. The non-agricultural uses include applications in aquatic areas, forests, dwellings, and indoor environments. The toxicological endpoints of primary concern are acute and subchronic cholinergic signs and localized skin effects observed in animal studies. Dichlorvos (DDVP), which is the initial metabolite of naled in the biotransformation process and an insecticide itself, is listed under California's Proposition 65 (the Safe Drinking Water and Toxic Enforcement Act of 1986) as a chemical known to the State to cause cancer. During the 15-year period between 1982 and 1996, there were a total of 145 illnesses or injuries reported in California as having an association with naled alone, or in combination with other pesticides. The symptoms involved in these cases were either eye and skin irritation only, or systemic and respiratory in nature, or all of the above. A rat study was submitted recently and evaluated, which suggested a dermal absorption of 35% as surrogate for humans. There were no studies available truly on inhalation absorption for naled. Available animal metabolism studies showed that naled was completely biotransformed to various metabolites while being distributed to all tissues, with about 40% and 10% excreted in the urine and the feces, respectively, within 48 hours after dosing. In this exposure assessment, the potential exposures to naled for the various activities were calculated for six major subpopulations which included residents, bystanders, applicators, mixer/loaders, flaggers, and field workers. Actual data on human exposure to naled were very limited. The daily exposures to naled for these individuals hence were calculated primarily from surrogate data. The highest calculated absorbed daily dosage was 0.9 mg per kilogram of body weight. This was the dosage calculated for agricultural workers applying naled with backpack sprayers while wearing chemical-resistant gloves and coveralls over normal work clothing (i.e., long pants, shoes plus socks, and a long-sleeved shirt). There were no exposure data available to calculate the dosages for ground or aerial applicators spraying naled with thermal/cold fog generators, mist blowers, or ultra low volume equipment in wide areas.

NEEDS FOR AND SCOPE OF SECOND REVISION

Exposure to DDVP (the major metabolite of naled) and seasonal exposure were the main topics added to the first revision. This second revision updates the list of naled products currently registered in California, revises the dermal absorption rate used in the exposure assessment, and adds a list of the unabsorbed dermal doses expressed in $\mu g/cm^2$. In June, 1999, the major basic registrant Valent USA sold most of their naled products to AMVAC Chemical. The unabsorbed dermal doses are provided here to more effectively account for the localized skin effects considered to be critical during the hazard identification process. In an effort to minimize any unnecessary inconsistency or errors that may result from possible oversight, the changes made in this revision were kept to the minimum and hence primarily in those places where such changes were thought to have an impact in the naled risk assessment process. To reflect as well as to account for these updates, the Abstract, the Introduction, Table 1 (Naled Products Registered in California), the Exposure Appraisal, and the References, plus a couple of places elsewhere in the document, were also necessarily revised slightly.

In previous versions, because there were no dermal absorption studies available for naled, absorbed doses from dermal exposure were calculated using the absorption default of 50%. Earlier this year AMVAC submitted an *in vivo* dermal absorption study of naled in the rat. This study was then promptly evaluated by the Worker Health and Safety Branch (Dong, 2000), which recommended that a dermal absorption rate of 35% be used to estimate the daily absorbed dose in persons from exposure to naled via the dermal route. As a result of this recommendation, the portions of Sections IX and XI-5 that are on dermal absorption were updated accordingly, so were the absorbed dermal doses listed in Table 4 (for residents and passersby), Table 5 (for field workers), Table 8 (for agricultural workers), and Table 9 (for non-production agricultural users).

The Exposure Appraisal section is expanded to include further elaboration on the expectation that the exposure of children to naled from pet collars is minimal. Further justification is deemed necessary and appropriate here, in light of the recent national perspective concerning children's health.

The Department's Medical Toxicology Branch oversees the hazard identification and the risk characterization processes. Since the completion of the first revision of this exposure assessment document, that branch has determined that additional assessment is necessary to address the localized skin effects observed 1 day (erythema) and 21 days (acute inflammation and acute ulcerative inflammation) following application of naled on the rat skin. In response to this health concern, this second revision thus adds in Section XIV (Addenda) four tables listing the relevant unabsorbed dermal doses in units of $\mu g/cm^2$ by body part. Also included in the new Section XIV is the Medical Toxicology Branch's justification as well as request for the inclusion of these new dermal exposure estimates.

The Appendices and the Addenda sections in this second revision serve a similar purpose. They are both a supplementary part of the document providing additional information to clarify or support certain issues. The only subtle difference is that here the addenda are considered to be the primary causes for which this second revision has been made.

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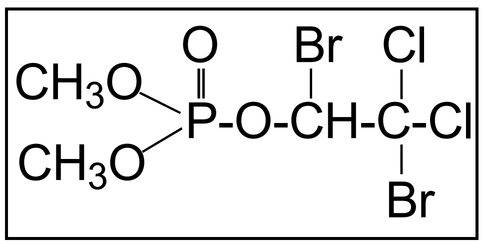
I. INTRODUCTION

Naled (1,2-dibromo-2,2-dichloroethyl dimethyl phosphate) is an organophosphate which has been used in California for control of insects and mites in a great variety of agricultural and non-agricultural settings. The primary biological activity of this insecticide is, like those of many other organophosphates, through its inhibition of cholinesterase (ChE) enzymes. Naled has been used on fruits, cotton, nuts, greenhouse ornamentals, and vegetables. Its non-production agricultural uses include applications in aquatic areas (e.g., marinas and swamps), forests, dwellings (e.g., hotels), and indoor environments (e.g., animal buildings, hospitals, factories, restaurants, warehouses, feedlots, and meat packing establishments). The assessment of occupational and non-occupational exposures for this active ingredient (AI) necessitated the construction of numerous use scenarios, some of which were considered for the first time in pesticide exposure assessment. This exposure assessment by the Worker Health and Safety Branch (WH&S) is written to be an integral part of the risk characterization document (RCD) prepared by the Department of Pesticide Regulation (DPR) for all uses of naled in California. The Department's risk characterization for naled is performed in part because of the insecticide's adverse effects observed in acute, (sub)chronic, dermal toxicity, and reproductive studies. The major adverse effects observed were cholinergic symptoms, which included dyspnea, inactivity, tremors, salivation, and death. Other adverse effects observed included localized reactions such as erythema, acute inflammation, and acute ulcerative inflammation from acute and subchronic exposure to the skin. Dichlorvos (DDVP), which is the initial metabolite of naled in the biotransformation process and an insecticide itself, is listed under California's Proposition 65 (the Safe Drinking Water and Toxic Enforcement Act of 1986) as a chemical known to the State to cause cancer. The potential exposure to DDVP as an active ingredient is addressed only briefly toward the end of this exposure assessment document, since a separate exposure assessment document (Fong and Formoli, 1993) has been completed for this metabolite.

II. PHYSICAL AND CHEMICAL PROPERTIES

Naled (1,2-dibromo-2,2-dichloroethyl dimethyl phosphate, CAS Registry No. 300-76-5, molecular weight 380.89, molecular formula $C_4H_7Br_2Cl_2O_4P$) is an organophosphate insecticide. This chemical is commercially available as a yellow liquid (with a pungent odor). Although naled has low water solubility (2 g/L at 22^oC), it can be completely hydrolyzed in water within 48 hours at room temperature. It is only sparingly soluble in petroleum solvents but is freely soluble in aromatic and chlorinated hydrocarbons, ketones, and alcohols. Its solubility in heptane at 20^oC is 82 g/L. The vapor pressure of naled is 2 x10^{-3} mm Torr at 20^oC, with a boiling point of 110^oC at 0.5 mm Hg and a melting point of 26.5 to 27.5^oC. Its specific gravity, Henry's Law constant, and octanol-water coefficient are 1.971 at 27.5^oC, 5.014 x 10^{-8} atm $m^3 g \cdot mol^{-1}$, and log P = 2.18 at 500 ppm, respectively, (all above properties as reported by Chevron Chemical Company, 1980, 1983a, 1983b, 1983c, 1983d, 1983e, 1987). The following is the chemical structure of naled:



III. FORMULATION/INTENDED USE PATTERN

Technical naled available in the United States was first manufactured by and registered to AMVAC Chemical Corporation in 1985. It is intended only for use in the formulation of other naled insecticide products. The registration of this technical was later transferred to Valent USA, under the trade name Valent® Naled Technical. This technical, along with a few naled products from Valent, is now registered to AMVAC again. The other naled products that are currently registered in California, together with the technical naled, are summarized in Table 1 below.

Of the 15 naled products currently registered in California, Dibrom® 8 Emulsive appears to have the broadest use. Its product label covers essentially all uses other than those included in Naled Technical, Dibrom® Concentrate, and those available as flea/tick collars for dogs or cats. The use of the flea/tick products involves simply placing or buckling the collar around the animal's neck. Unlike the technical, Dibrom Concentrate cannot be diluted with water, but can be diluted with diesel oil and applied with ultra low volume equipment. This concentrate is a special formulation designed for control of mosquitoes, houseflies, and certain other nuisance insects.

As shown in Table 1, Dibrom 8 Emulsive contains 62% of naled by weight, or 7.5 lb naled AI per gallon of the emulsive. To facilitate the discussion of the present exposure assessment, the agricultural commodities to which this emulsive product can be applied may be divided into 6 crop groups: (1) vines (e.g., grapes, *typically by airblast or over-the-vine boom*); (2) vegetable/row crops (e.g., broccoli, cabbage, celery, eggplant, strawberries, summer squash, etc., *by air or groundboom*); (3) field crops (e.g., cotton, cantaloupes, muskmelons, melons, safflower, sugar beets, beans, etc., *by* *air or groundboom*); (4) orchards (e.g., almonds, walnuts, oranges, lemons, peaches, etc., *by air or airblast*); (5) forestry (e.g., shade trees, ornamental shrubs, flowering plants, etc., *by hand-held type*); and (6) greenhouse crops (e.g., roses and other ornamentals, *by vapor from hot pipes or pans*).

Table 1. Naled Products Registered in California[a]

EPA Reg. No.	Product Name	Company Name	%AI/Net Contents
2517-44-AA	Bansect® Flea & Tick for Cats	Sergeant's Pet Products	10.0%/14 g in 1 collar
2517-43-AA	Bansect® Flea & Tick for Dogs	Sergeant's Pet Products	15.0%/25 g in 1 collar
2517-46-ZA	Sergeant's® Dual Action Flea & Tick Collar for Cats	Sergeant's Pet Products	7.0%/14 g in 1 collar
2517-45-ZA	Sergeant's® Dual Action Flea & Tick Collar for Dogs	Sergeant's Pet Products	15.0%/25 g in 1 collar
2517-46-ZB	Sergeant's® Flea-Brites Flea & Tick Collar for Cats	Sergeant's Pet Products	7.0%/14 g in 1 collar
2517-45-ZB	Sergeant's® Flea-Brites Flea & Tick Collar for Dogs	Sergeant's Pet Products	15.0%/25 g in 1 collar
59639-18-AA-2393	Hopkins® Fly Killer D	HACO, Inc.	36.0%/1 gal
34704-351-AA	Clean Crop Dibrom® 8 Miscible Naled Insecticide	Platte Chemical Co.	58.0%/1 gal
5481-479-AA	Dibrom® 8 Emulsive	AMVAC Chemical	62.0%/(*not given*)
5481-480-AA	Dibrom® Concentrate	AMVAC Chemical	87.4%/(*not given*)
5481-482-AA	Fly Killer D®	AMVAC Chemical	36.0%/(*not given*)
5481-478-AA	Naled Technical®	AMVAC Chemical	90.0%/(*not given*)
5481-481-AA	Trumpet® EC Insecticide	AMVAC Chemical	78.0%/(*not given*)
59639-15-ZA	Legion® Insecticide	Valent USA	58.0%/5 gal
59639-18-AA	Valent® Fly Killer D	Valent USA	36.0%/1 gal

[a] those registered to AMVAC Chemical and Sergeant's Pet Products were previously registered to Valent USA and ConAgra Pet Products, respectively; AI ≡ active ingredient.

Uses of Dibrom 8 Emulsive other than the above are likewise numerous; they can be further subdivided into residential and predominantly non-residential. These residential and non-residential sites include shade trees, shrubs in lawns, swamps, livestock pastures, feedlots, holding pens, woodlands, cull piles, refuse areas, food processing plants, and loading docks. Dibrom 8 Emulsive is used at these sites mainly to control flies or mosquitoes, in addition to clover mites, roaches, earwigs, leafhoppers, or other insects and mites. In or around food processing plants, this emulsive is applied to walls, doorways, windows, and cull piles using a coarse sprayer or by injection; otherwise, for control of flies and mosquitoes in open fields, mist or thermal fog by aircraft and ground equipment is typically used. Applications at other (non-production agricultural) sites usually can be made with either ground or hand-held equipment.

IV. REGULATORY HISTORY/STATUS

Naled was introduced in 1956 by Chevron Chemical Company (Gallo and Lawryk, 1991), with Orthocide Dibrom® 10-4 Dust in 1966 being the first end-use product registered in California (now no longer available in the State). In 1990, the U.S. Environmental Protection Agency (USEPA, 1990) granted the U. S. Department of Agriculture a quarantine exemption for the use of naled baits as a means to eradicate the oriental fruit fly *Dacus dorsalis* and other *Dacus* spp. in California. The following conditions were specified for the quarantine exemption use: At least 600 bait spots per square mile; no applications to food or feed crops; a reapplication interval of 2 weeks or longer; and an expiration date of December 2, 1992.

USEPA (1995a) established a reference dose (RfD) of 0.002 mg/kg/day for chronic exposure to naled. This RfD was based on the cholinesterase inhibition observed in rat brain in a two-year dietary study, in which a NOEL (no observed effect level) of 0.2 mg/kg/day was found. According to the California Code of Regulations (1991), the PEL (Permissible Exposure Limit) of naled in the workplace is 3 mg/m^3, or 0.19 ppm, at 25^{o}C and 760 mm Hg.

USEPA (*Code of Federal Regulations*, 1999) also established residue tolerances of ≥ 0.5 ppm (parts per million) for naled present in/on raw agricultural crops and 0.05 ppm for naled in/on meat-related commodities. A Reregistration Eligibility Decision review for naled was issued by USEPA (1995a) on July 13, 1995.

V. USAGE IN CALIFORNIA

Naled is not a restricted pesticide in California. As such, only licensed pest control operators were required to report its usage prior to 1990. Now with a few exceptions, commercial users must report pesticide use. According to the annual pesticide use reports (DPR, 1994, 1995, 1996a, 1996b, 1999), from 1992 through 1996 more than 70% of the total reported annual usage was for production agricultural uses. In 1995, 79% of the total reported annual usage was on cotton alone. (Note that there was a data entry error in listing the annual usage for cotton in the original 1994 hardcopy annual pesticide use report.) Table 2 below lists the 1992 through 1996 annual usage of naled in California by pounds and by number of applications.

The raw agricultural commodities with the 8 highest *percent* pound usage (as determined for the majority of the earlier years) are listed in Table 3 below. As indicated in Table 3, since 1994 annual usage on cotton continued to be the highest among all crops and sites. For non-production agricultural sites, animal husbandry premises topped the 1996 list, taking up approximately 3% of the reported total annual naled usage in California. In 1996, the use of naled on almonds also reached 6% of the reported total annual usage.

The annual pesticide use reports do not cover pesticides used as flea/tick killers or fly killers. To some extent, the annual usage for these unreported sites can be approximated from the mill assessment (sales) data which showed that, for the past several years, less than 5% of the annual sales have been for flea/tick and fly killer products. Of these minor sales, the market share of flea/tick naled collar products has been 1% or less.

Table 2. Annual Usage of Naled in California From 1992 Through 1996, by Pounds and by Number of Applications[a]

	Pounds	Number of Applications
1992	164,905	6,731
1993	180,041	5,368
1994	460,222	9,992
1995	711,519	11,944
1996	351,266	6,607

[a] based on the Department's pesticide use reports (DPR, 1994, 1995, 1996a, 1996b, 1999).

Table 3. Raw Agricultural Commodities With the 8 Highest Percent Usage in Pounds (Based on the Earlier Years) From 1992 Through 1996[a]

Commodity	1992	1993	1994	1995	1996[b]
fresh market grape	14	7	5	1	1
processed grape (wine)	6	4	2	1	1
orange	14	12	4	2	3
safflower	7	14	4	2	6
strawberry	9	7	2	2	3
cotton	11	15	65	79	58
broccoli	3	2	4	2	4
sugarbeet	4	5	2	1	2

[a] for actual (absolute) usage in pounds, simply multiply the year's total pounds listed in Table 2 by the percentage listed in this table.

[b] in 1996, the use of naled on almonds also reached 6% of the reported annual usage.

VI. LABEL PRECAUTIONS

All of the naled products listed in Table 1, except those with limited usage, are labeled as toxicity Category I pesticides with the signal word DANGER. The exceptions are the flea collar products, all of which are classified as having Category III (CAUTION) toxicity. According to the labels as well as the newly-adopted worker protection standard (WPS), workers are required to wear chemical-resistant gloves, long-legged pants, shoes plus socks, protective eyewear, chemical-resistant headgear (for overhead exposure), and a long-sleeved shirt when handling naled products having Category I toxicity. The toxicity Category I products are labeled as corrosive to eyes and the skin. In California, a closed system must be used when mixing/loading pesticides having Category I toxicity if their usage per application exceeds 1 gallon.

The labels for the toxicity Category I products advise that large amounts of water be given to the victim if he or she accidentally swallows the product. For eye and dermal contact, the labels recommend flushing the affected areas with large quantities of running water for at least 15 minutes. If poisoning is through inhalation, the victim should be immediately removed from the contaminated atmosphere. In all cases, medical attention should be sought as soon as possible. For the toxicity Category III products, clothing requirements for users are not specified but the labels reflect similar precautionary statements, especially on the part pertaining to eye and skin contact.

Technical grade naled has caused mild skin sensitization in guinea pigs (USEPA, 1995b; Knaak, 1984). Despite these findings, the labels for *some* of the naled products listed in Table 1, primarily those having Category III toxicity, do not contain a precautionary statement warning that the insecticide may cause allergic skin reaction in humans.

VII. WORKER ILLNESSES AND INJURIES

Annual cases of illness and injury that have been reported by California physicians or health authorities as related to pesticide exposure have been compiled for 1982 through 1996. During this 15-year period, a total of 145 cases were reported as having an association with naled alone, or in combination with other pesticides (Mehler, 1999).

In 1995, a drift episode occurred in Kern County, in which 22 employees working in a potato packing house developed symptoms after odors were produced from misapplications of naled and two disinfectants (Verder-Carlos, 1999). Many of their symptoms were systemic and respiratory in nature. The pesticides were misused (i.e., contrary to label instructions) to control infestation of stagnant water kept in an unused tank in the packing house. In addition to this drift episode, four other cases were also reported in 1995 to have been related to the use of naled.

A review of all 145 cases by the WH&S staff in the Pesticide Illness Surveillance Program (Verder-Carlos and Mehler, 1999) indicated that more than half of these illnesses and injuries were due to accidental applications of the organophosphate onto the patients' face, to their contact with (foliar) dislodgeable residues, or to spray drifts. The symptoms for 59 of these 145 cases (i.e., slightly over 40%) were eye and skin irritation only. For the 86 cases reported as having systemic symptoms, 56 cases were tested for cholinesterase levels. Of the 56 cases tested, 11 cases had no results available, 6 cases had levels below the baseline, 5 cases had levels below the normal range, and another 2 cases had levels below the midpoint of the normal range. Of the remaining 32 cases whose levels were reported to be within the normal range, 28 cases furnished test reports.

VIII. ACUTE DERMAL AND RELATED TOXICITY

According to USEPA (1995b) and the Medical Toxicology Branch (Berliner *et al*., 1985), the acute dermal LD_{50} for technical naled was 360 mg/kg (Category II) in female rabbits and 390 mg/kg (Category II) in male rabbits. The acute inhalation LC_{50} for 4 hours of exposure to technical naled were 0.19 (Category II) and 0.20 mg/L (Category II) in female and male rats, respectively. In addition, USEPA considered the eye and the dermal irritation observed in rabbits to be severe (Category I). Their reported acute oral LD_{50} ranged from 92 mg/kg (Category II) in female rats to 325 mg/kg (Category II) in male rats. As mentioned in Section VI, technical grade naled was noted to have caused mild skin sensitization in guinea pigs.

IX. DERMAL AND INHALATION ABSORPTION

There is one *in vivo* dermal absorption study submitted recently in support of the reregistration of naled (Jones, 1999). Rats and Dibrom-8 were used in this study as test species and test substance. A review (Dong, 2000) of the study recommended that an absorption rate of 35% be used to estimate the daily absorbed dose in persons from exposure to naled via the dermal route, until and unless acceptable human or further animal dermal absorption data have become available. As a result of this recommendation, in this exposure assessment the calculations (where needed) of all absorbed dermal doses were based on this absorption rate. In the previous versions of this exposure assessment document, the default absorption rate of 50% (Donahue, 1996) was used for lack of naled dermal absorption data. Also, it is of note that earlier the Department was not incorrect in rejecting the proposal from Valent USA (1995a), that an absorption rate of 20% be used for calculation of dermal exposure to naled.

For inhalation uptake and intake for many chemicals, the default values used by WH&S are 50% and 100%, respectively (Thongsinthusak *et al*., 1993a). Since there were no studies available truly on inhalation absorption for naled, these absorption defaults were used here to calculate the inhalation exposures to naled.

X. ANIMAL AND HUMAN METABOLISM

No metabolism studies were submitted by Valent USA or by other registrants for evaluation of naled's biotransformation observed directly in humans, as such human studies apparently had never been conducted or reported. Valent USA did provide four animal metabolism studies on naled. Rats (Cheng, 1981a, 1981b), goats (Chen, 1982), and chickens (Cheng, 1983) were the three species used separately in the four animal studies. Valent USA also provided a short summary report on the results of these studies (Abell, 1985). The use of dogs and cows as test species for metabolism study was mentioned, but without much detail.

In all the species tested, naled was found completely biotransformed to various metabolites while being distributed to all tissues. The metabolic pathways proposed by the investigators for these species were similar. For simplicity, only the major metabolic pathways for rats alone are depicted in Figure 1 below. As shown in this figure, initially naled is metabolized to DDVP, which is then hydrolyzed to dichloroacetaldehyde (DCA).

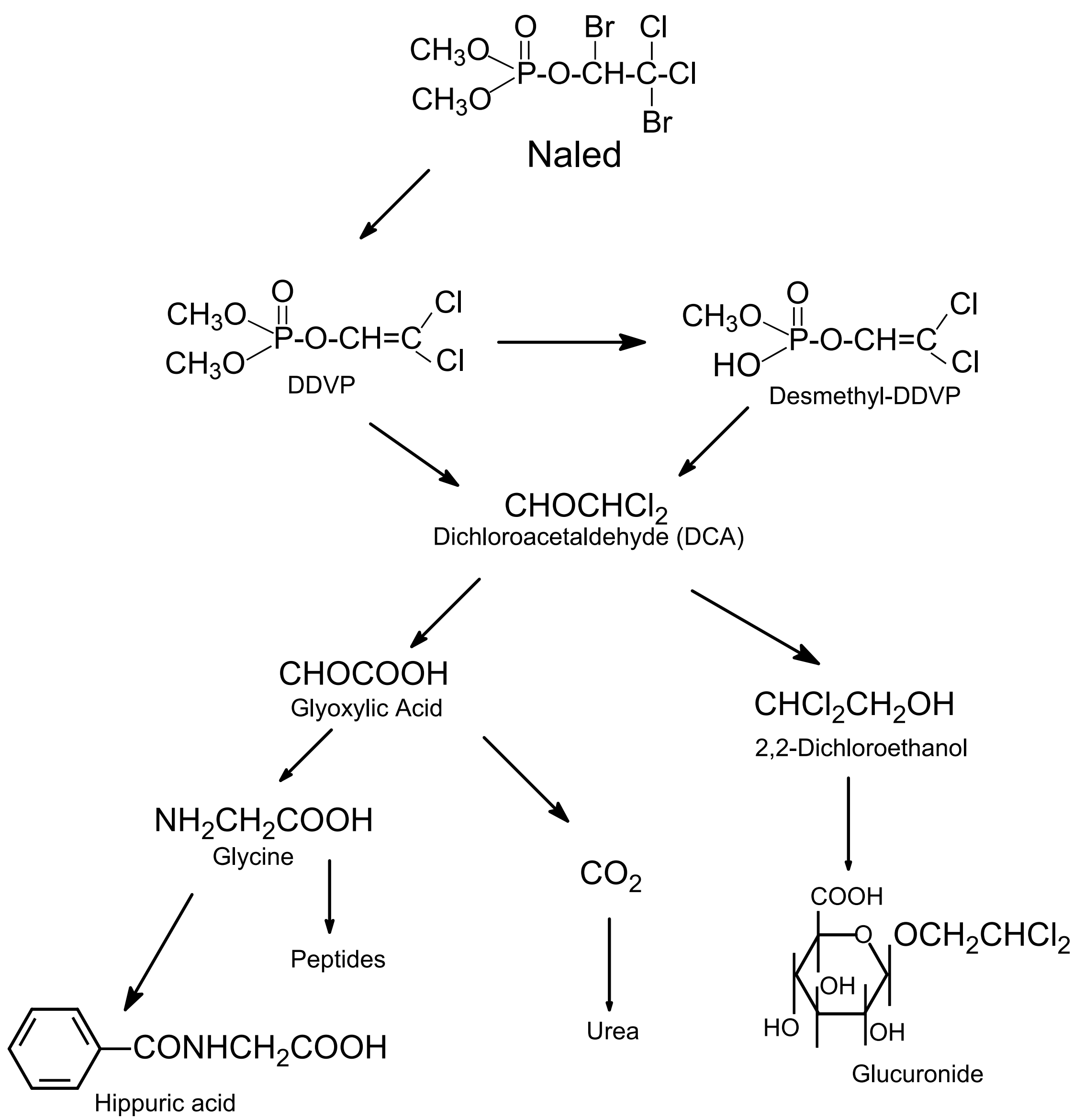


Figure 1. Major Metabolic Pathways of Naled in Rats as Proposed by Valent USA (Cheng, 1981a; Abell, 1985)

In the first (Cheng, 1981a) of the two rat studies cited above, the test animals were orally treated with [Ethyl-^{14}C]naled at 28 and 50 mg/kg for the excretion pattern. Two days after dosing, ~ 40% of the radioactivity was reportedly excreted in the urine, ~ 10% in the feces, 20 to 30% in the expired air, and 20 to 30% remained in the carcass. According to the investigator, ~ 90% of the amount excreted in urine was characterized as a conjugate of 2,2-dichloroethanol, probably of a glucuronide type. Similar findings on the 48-hour recovery of radioactivity in the urine were observed in the second rat study (Cheng, 1981b), in which the animals treated with a single oral dose at ~ 25 mg/kg were sacrificed at 2, 6, 24, and 96 hours after dosing. In this second, more extensive metabolism study, 5.3% of the applied radioactivity was found in the urine at 2 hours after dosing.

XI. EXPOSURE ASSESSMENT

XI-1. Ambient Air

In mid 1991, Air Resources Board (ARB) contracted out a monitoring study (Royce *et al*., 1993) in which ambient naled air levels were measured at five sampling sites located in central Tulare County. The highest naled level and DDVP level measured over a 24-hour period in this 1991 study were, respectively, 0.08 and 0.06 $\mu g/m^3$. The 1991 usage of naled in Tulare was the second highest by county, over 80% of the annual amount (38,000 lb) used in Fresno County. Although between 1994 and 1996 the annual naled usage in Tulare dropped slightly in rank, in 1996 the total amount of naled applied in Tulare was approximately 40% of the county's total naled applied in 1991 (based on the Department's annual pesticide use *electronic* database).

In terms of inhalation exposure to naled, a maximum air level of 0.08 $\mu g/m^3$ suggests that a *six-year-old child* would receive at most an absorbed daily dosage (ADD) of 0.03 µg per kilogram of body weight. This dosage estimation was based upon a 24-hour average inhalation rate of 16.7 m^3/day (USEPA, 1997), an average body weight of 21.7 kg (USEPA, 1997), and an inhalation uptake of 50% (*see* Section IX). This dosage estimation was calculated as follows:

$$\text{ADD} = 0.03\ \mu g/kg/day = [(0.08\ \mu g/m^3) \times (16.7\ m^3/day)) \times (50\%) \times (21.7\ kg)^{-1}].$$

For *adults*, the ADD derived from the above maximum naled air level was 0.01 µg/kg. This three-fold difference in absorbed naled dosage was strictly a result of using the smaller ratio of the default average inhalation rate (16.0 m^3/day) to average body weight (70 kg) assumed for adults. It was due to this rate-to-weight ratio that a six-year-old was used to represent the children population.

XI-2. Residents/Bystanders

Table 4 below is presented for quick reference summarizing the potential exposures to naled estimated for bystanders and non-user residents staying at or around the treatment site. Some of the assumptions used in the estimations are consistent with common practice and hence are mentioned as table footnotes only. Others that require clarification or appear to be unique to this population subgroup or to naled are discussed below, along with a brief description of the exposure estimations involved.

Children. Naled is commercially available as a flea and tick collar for cats and dogs. There is thus a potential for young children to be exposed to naled dust impregnated in the collars, provided that they are allowed to pet animals wearing these collars. Surrogate data are not available for this type of exposure assessment for any pesticide. It is anticipated, however, that such exposure would be insignificant if occurring at all. For one thing, parents are not supposed to let their children near or share pillows or the like with pets whose body is found to have fleas or ticks (and have the collar on). The effect of collar treatment is not meant to be instantaneous since, as stated on the naled product labels, the collar should be used continuously to attain maximum efficacy. It is also a known fact to many people that unlike fleas, ticks are relatively harder to kill and die more slowly. In addition, the product labels specify explicitly that children are not allowed to play with these collars.

Table 4. Daily Exposure to and Absorbed Daily Dosage of Naled Estimated for Bystanders and Non-User Residents at or Near Treatment Sites

Subgroup	No. of Days[a] Exposed per Year	Daily Exposure[b] (mg/kg BW/day)	Absorbed Daily Dosage[c] (μg/kg BW/day)	Seasonal Daily Dosage[d] (μg/kg BW/day)
Adult Residents	4	< 0.06	< 20	< 4.0
Children[e]	4	< 0.06	< 20	< 4.0
Non-User farmers[f]	4	< 0.06	< 20	< 4.0
Bystanders[g]	4	< 0.06	< 20	< 4.0

[a] based on the expectation that at most 2 to 3 applications will be made per season and that the naled airborne or surface residues will dissipate substantially after 2 days post application (*see* discussion in this section).

[b] back calculated from absorbed dosage, based primarily on a dermal absorption of 35% and less on an inhalation uptake of 50% (*see* Section IX).

[c] estimated primarily from the biomonitoring data presented in the Delaware study (Kutz and Strassman, 1977), as discussed in this section for adult residents.

[d] *presented for completeness only*, since the seasonal frequency of 4 days is generally not considered to be adequate to induce the subchronic effect of concern when this effect was in fact observed in a 21-day rat study (per e-mail from Lori Lim of the Medical Toxicology Branch dated 02/10/99, and *see* Section XIV; for annualized average daily dosage, the estimates would be < 0.22 μg/kg BW/day, or 18 times (i.e., per 20 days *vs*. per 365 days) lower than those calculated here for the seasonal dosage.

[e] included for this group were exposures from soil ingestion and from hugging animals with treated collars on.

[f] including non-user growers whose crops are treated by commercial applicators.

[g] including chefs, cooks, waiters, bus boys, and food service personnel, whose restaurants or food plants are treated for control of flies, mosquitoes, and other pests.

Inhalation of airborne naled residues could also be a possible route of exposure for children playing in treated areas. Naled is considered as a volatile chemical (*see* Section II), which suggests that its residues on soil could act as a source of potential inhalation exposure. There are no data available on airborne or soil residues present on residential properties treated with naled. However, exposure of children to naled via inhalation can be alleviated to a great extent if certain reentry procedures and sound application practices are followed.

There was indication that the airborne residues did not dissipate rapidly enough during the first 48 hours after naled was applied to an orange grove (ARB, 1995). It is important to note that in addition to their dissipation pattern, the level of airborne pesticide residues is a function of application *rate* and *usage*. The orange grove data showed that following application, the naled air concentrations ranged from 0.02 $\mu g/m^3$ to a maximum of 6.30 $\mu g/m^3$. The application rate (0.94 lb per acre) used for the orange grove treatment was nearly 10 times that typically used for residential treatments. The average air concentration from a typical treatment made in residential areas is thus expected to be less than 0.63 $\mu g/m^3$. Based on the algorithm presented in Subsection XI-1, the ADD would be less than 0.25 μg/kg/day.

In addition to the control for houseflies and mosquitoes, naled can be applied directly to turf and soil surfaces around flowers, shrubs, and trees in residential areas for eradication of other general pests, such as clover mites and earwigs. Due to naled's high vapor pressure (*see* Section II), its residues present in or on soil and turf from this type of residential treatments are expected to be transient, if in any significant quantity at all.

Although data on naled soil residues were not available to WH&S, the maximum naled concentration in residential soil was expected to be less than 1 mg/kg, or 1 ppm. This expectation was based on the label specification that naled is applied in residential areas at a rate normally not to exceed 0.1 lb AI per acre, or approximately 1 mg per sq ft. Since the density of soil of most any type is around 1.6, 1 square foot of soil with a depth of 0.25 inch would weigh about 1,000 g (i.e., 1,000 g ≈ [12 x 12 x 0.25 cu in] x [cu cm/0.06 cu in] x 1.6 g/cu cm). This suggests that the initial deposition of naled in residential soil normally would not exceed 1 mg/kg, or 1 ppm. At this maximum soil concentration and the mean soil ingestion rate of 200 mg/day (USEPA, 1997; Dong *et al*., 1994), the oral ADD of naled through soil ingestion by a six-year-old child would be less than 0.01 μg/kg/day. Even at a much higher daily soil ingestion rate of 10,000 mg for pica problem (i.e., abnormal mouthing behavior), the daily soil intake of naled by this child would still be less than 1 μg/kg/day.

Adult Residents. In a biomonitoring study by Kutz and Strassman (1977), the mean urinary level of dimethyl phosphate (DMP) was found to have increased from 0.005 to 0.014 ppm (i.e., a net gain of 0.009 ppm) in 56 volunteers after an aerial application of naled for mosquito control near Dover, Delaware. These volunteers stayed outside of their houses within the treatment area. The maximum net increase among this subgroup was 0.44 ppm, or 440 μg per liter of urine. There was no noticeable increase (as a group) observed in the DMP levels in other volunteers who either stayed outside of the treatment area or remained indoors (but within the treatment area).

Altogether two groups of volunteers whose ages ranged from 4 to 83 years old were included in the above Delaware study, in which naled was applied at approximately 0.05 lb AI/acre, along with a trace amount (< 0.002 lb/acre) of temephos. There were 107 volunteers staying inside the actual spray target area and 100 others staying in a 1 mile margin outside the treatment zone. Two urine specimens were collected from each of these 207 volunteers, with one collected at several hours prior to application and the other collected at within 3 hours after the application. Of six metabolites detected in the study, DMP and DMTP (dimethyl phosphorothionate) were specifically used as indicators of exposure to naled and temephos, respectively. As shown in Figure 1 in Section X, naled cannot be converted to DMTP since the former lacks the thiol group. For this reason, the average increase of 0.009 ppm in DMP noted in 56 of the 107 volunteers (i.e., of all those in the first group that stayed outdoors but inside the spray target area) is thought to be due more to their exposure to naled than to temephos, especially when the latter insecticide was applied only in trace amount. Even under this worst case assumption (that *all* of the DMP came from naled), the exposure to naled from aerial sprays applied at 0.05 lb/acre would be at most 13.5 μg per day based on a maximum daily urine output of 1.5 liter for adults (i.e., 13.5 μg/day = 9 μg/L x 1.5 L/day). This is equivalent to an absorbed dose of 40.5 μg naled per adult since the molecular weight (380.0) of naled is 3 times that (125) of DMP.

From the estimate of 40.5 μg/adult calculated above, the absorbed daily dosage (ADD) of naled is expected to be about 20 μg per kilogram of body weight (BW). This expectation is based on the fact that for mosquito control in California, the product label allows up to 0.1 lb of Dibrom Concentrate (which contains 87.4% of the naled active ingredient) to be applied per acre of area. It is also based on the observation in animal studies, as stated in Section X, that 5% of the absorbed dose would be excreted in the urine at 2 hours after dosing. (That is, ADD ≤ 20.0 μg/kg BW [= 40.5 μg x (0.1 lb/0.05 lb) x (87.4%) x (5% for incomplete urine collection)$^{-1}$ x (70 kg)$^{-1}$]). *Note that this absorbed daily dosage of 20 μg/kg BW is applicable to young children as well*. The DMP levels measured in the 56 volunteers in the Delaware study were not given by age. However, it is expected that few, if any, of the young children would be among those who remained outdoors during the aerial application. Also, young children's daily urine output is about 3 times less than the maximum amount assumed above for adults. This difference in daily urine output, together with young children's usual limited duration of outdoor activities, is sufficient to offset much of the disparity in body weight between young children and male or female adults.

It was mentioned earlier that the maximum level of DMP observed among the 56 volunteers was 0.44 ppm (after adjustment for baseline value). A more conservative value for the daily absorbed dosage hence would be 1 mg/kg BW (i.e., ≈ 977.8 μg/kg BW [= (20.0 μg/kg BW) x (0.44 ppm/0.009 ppm)]). However, this value is considered highly unrealistic in that there was apparently only one individual receiving such high exposure. Even though there were no individual data given, it is intuitive that the DMP levels from the other 55 volunteers (plus the remaining 51 = 107 − 56 volunteers in the same group) were *well* below their average of 0.009 ppm (after adjustment for their baseline values). Otherwise, their arithmetic mean could not have been this low since the total from the 56 volunteers altogether was only 0.50 ppm (= 0.009 ppm x 56). Despite this statistical implication, the rather conservative DMP average of 0.009 ppm was used here because if not used, the daily dosage could have been underestimated since the urine samples were collected within the first couple of hours, though during which time dermal and inhalation exposures to aerial type application are supposed to be at their peak (partly due to residue fall-out and partly due to rapid residue dissipation).

Non-User Farmers/Growers. Naled formulated as emulsive can also be applied to reduce livestock pests in corrals, holding pens, feedlots, and rangelands that contain dairy and beef cattle, hogs, sheep, or horses. Even though the maximum label rates for these sites are nearly 3 times that allowed for mosquito control in residential areas, the maximum daily exposure to naled received by farmers who themselves are not applicators is expected not to exceed the dosage of 20 μg/kg BW calculated above for non-user residents. This expectation is based on the presumption that these bystander farmers have a greater opportunity (or are better advised as through one-on-one instructions) to stay away from the sprays during the first few hours of (livestock) treatment. This argument also holds true for growers whose crops are treated by commercial applicators.

Other Bystanders. Potentially, chefs, cooks, waiters, waitresses, bus boys, food service workers, and the like can be exposed to naled when they return to restaurants or to food processing plants treated with naled. However, daily exposure to naled for these other bystanders is not expected to be as much as that received by adult residents staying in an area that has been treated for mosquito control. This is because normally it will be many hours after treatment before these individuals return to work. Reentry restrictions have been proposed by USEPA (1995c) for homeowner and non-WPS (i.e., non-worker protection standard, implying non-agricultural) occupational uses of naled products. These include labeling language that restricts people from touching treated livestock, plants, soil, or other surfaces until the sprays have dried.

XI-3. Field Workers

Several groups of field workers are subject to occupational exposure from contact with dislodgeable naled residues present on treated foliage. These include harvesters for various crops, cotton scouts, and those field workers who perform cane or shoot turning, leaf pulling, cane thinning, or girdling especially in vineyards. Data on reentry exposure to naled for these field workers were not available to WH&S, except for grape harvesters. For other field workers, it is thus necessary to extrapolate the dermal exposure from available dislodgeable foliar residue (DFR) data. This extrapolation was accomplished by means of a dermal transfer rate, which is defined here simply as the ratio (or sometimes some other relation, such as linear regression) of hourly dermal exposure (µg/hr) to DFR (µg/cm^2) measured more or less at the same time. The term DFR is defined as the amount of pesticide residues that can be removed from *both* sides of treated leaf surfaces using certain standard aqueous surfactant and mechanical agitation. When multiplied with a proper dermal transfer rate, the DFR under study may be readily converted to hourly (or daily) dermal exposure of workers entering a treated area.

Table 5 below summarizes the dermal exposures to *total* naled foliar residues that were calculated using the extrapolation method just described. Total naled residues were determined by adding the DDVP foliar residues in Table 6 to the naled foliar residues provided in that same table. The rationale for this addition is given in Subsection XI-5 (under Exposure to DDVP). The dermal transfer rates used for the various groups of field workers are justified in the subsections below. Also included in Table 5 are the various inhalation exposures estimated from air samples collected in vineyards sprayed with naled at 0.9 lb AI per acre.

To this date, there has been only one foliar residue study submitted for extrapolation of dermal exposure to naled. That study was conducted by Pan-Agricultural Labs, Inc. of Madera, California in the summer of 1993 (Rosenheck and Cone, 1994a), with Dibrom 8 Emulsive applied to mature Thompson seedless raisin grapes at two sites in the San Joaquin Valley. Each trial site included eight rows of treated vines plus one row serving as controls. Three applications of the naled emulsive were made at 7 day intervals at each site, at the maximum label rate of 0.9 lb AI per acre. Leaf disc samples for measuring foliar dislodgeables were collected at 8 intervals through 14 days following treatment. The results from the study indicated that both naled and its first major metabolite DDVP (dichlorvos) dissipated to about the minimum quantifiable limit (2.5 ηg/cm^2) by 3 DAT (days after treatment). Table 6 below lists the average levels of naled foliar residues observed for the first 6 sampling days (i.e., 0 to 5 DAT). The timed dissipation of these foliar dislodgeables is depicted graphically in Figure 2, in which the coefficients from the conventional log-linear regression are also given.

Table 5. Daily Exposure to and Absorbed Dosage of Total Naled for Various Field Workers, by Crop Type or Cultural Operation[a]

Field Workers	Daily Exposure Dermal[b]	Inhalation[c]	Absorbed Daily Dosage[d]	Seasonal Dosage[e]	Annualized Dosage[f]
Grape Girdler/Thinners[g]	1,240	13.4	6.3	2.71	0.51
Grape Harvesters[h]	115	4.5	0.6	0.27	0.13
Cotton Scouts[i]	372	10.1	1.9	0.81	0.11
Vegetable Crop Harvesters[j]	1,984	13.4	10.0	4.30	3.56
Greenhouse Harvesters[k]	44,800	13.4	224.1	96.32	46.1

[a] for workers wearing long-pants, shoes, socks, and a *short*-sleeved shirt without gloves; except perhaps for *greenhouse* plants, naled residues at 3 DAT (days after treatment) and thereafter are expected to be negligible or not detectable.

[b] in µg/person per 8-hour workday except for cotton scouts, whose workday was assumed to be 6 hours (*see* Dong *et al*., 1991; Dong, 1993, 1994).

[c] in µg per person per 8-hour workday except for cotton scouts (*see* footnote *b* above); calculated from total hourly inhalation exposures at 1 DAT (or at 3 DAT for grape harvesters) presented in Table 7 below.

[d] in µg/kg BW/day; based on a dermal absorption of 35% and a default inhalation uptake of 50% (*see* Section IX), on an adult male/female average body weight (BW) of 70 kg; and on the algorithm: Absorbed Daily Dosage (ADD) = [(Dermal Exposure) x (35% absorption) + (Inhalation Exposure) x (50% uptake) x $(BW)^{-1}$].

[e] in µg/kg BW/day; based on (roughly) one-half of the residue levels observed at day 1 (or day 3 for grapes) since the reapplication interval is typically 7 days and dissipation data (other than grapes) were not available to give a more accurate estimate for the foliar residue level over the first 7 days post application; and on the amortization factor of 0.86 for working 6 out of 7 days per week, given that the annual exposure frequencies listed below (*see* footnote *f*) are 40 days or higher and that the time-to-effect for the subchronic effect at issue was 21 days (per e-mail from Lori Lim of the Medical Toxicology Branch dated 02/10/99 and *see* Section XIV). [Overall, seasonal dosage = (1/2) x ADD x (6/7) = 43%(ADD).]

[f] in µg/kg BW/day; based on (roughly) one-half of the residue levels observed (*see* footnote *e* above) and on the amortization factor of AEF/365, where the annual exposure frequencies (AEF) are as follows: 40 days for cotton scouts (Dong, 1994); 60 days for grape girdler/thinners; 150 days for greenhouse harvesters (Dong, 1994) and grapes; and 260 days for other (i.e., mainly vegetable/row crop) workers who throughout the year may harvest *multiple* crops/fields treated with naled. [Overall, annualized dosage = (1/2) x ADD x (AEF/365) = (ADD) x (0.00137) x (AEF).]

[g] based on 8 hours/day, on an average dermal transfer rate of 5,000 µg/hr per µg/cm^2 (*see* discussion in this section), and on total naled and DDVP foliar residues of 0.031 µg/cm^2 at 1 DAT (as shown in Table 6 below).

[h] based on 8 hours/day and from hourly exposure to total naled and DDVP combined at 3 DAT presented in Table 7 below, as there is a PHI (pre-harvest interval) of 3 days for grapes.

[i] based on 6 hours/day (*see* footnote *b* above), on an average dermal transfer rate of 2,000 (*see* discussion in this section), and on total naled and DDVP foliar residues of 0.031 µg/cm^2 at 1 DAT (as shown in Table 6 below).

[j] based on 8 hours/day, on an average dermal transfer rate of 4,000 (*see* discussion in this section), and on total naled and DDVP foliar residues of 0.062 µg/cm^2 at 1 DAT (which is twice that shown in Table 6 below because the maximum application rate for row crops is twice that for grapes; note that strawberry pickers are included in this field worker subgroup).

[k] based on 8 hours/day, on an average dermal transfer rate of 7,000 (*see* discussion in this section), and on total naled and DDVP foliar residues of 0.8 µg/cm^2 at 0 DAT (*see* discussion in this section for use of 0 DAT even though the PHI is 24 hours).

During the second trial, which occurred in late August, 1993, an exposure study was conducted concurrently by Pan Agricultural Labs (Rosenheck and Cone, 1994b) for harvesters entering the treated vineyard sites. A total of 10 volunteers (2 laborers from Pan Agricultural Labs and 8 local vineyard harvesters) were monitored for dermal and inhalation exposures to naled using whole-body dosimetry (i.e., long underwear), handwashes, facial swipes, and typical personal sampling air pumps. During each replicate, the 10 volunteers all wore a clean pair of long-legged cotton pants and a clean long-sleeved cotton/polyester shirt (over their long underwear dosimetry), shoes plus socks, and some sort of hat. These harvesters used picking knives to cut the grape clusters from the treated vines. In order to reach all of the bunches from both sides of the vine, the harvesters also had to climb into and under the vines, thus necessarily coming into extensive contact with the treated foliage.

The above reentry exposure study was reviewed by Versar, Inc. (Dawson, 1995) for USEPA. According to Versar, the (actual) dermal transfer rate for the 10 workers, based on arithmetic means (of exposure rates monitored for the volunteers), was approximately 7,500 (µg/hr per µg/cm^2), with a 95% upper limit of 11,000. For DDVP, the average transfer rate and the upper limit were about 10% lower. These estimates for transfer rate were found acceptable to WH&S, since they are consistent with those observed (Welsh *et al*., 1993) for various other pesticides and by DuPont (Dong *et al*., 1992) for methomyl. The average exposure rates recalculated by WH&S for the 10 volunteers are presented in Table 7 below.

Table 7 shows that the (arithmetic) mean inhalation exposure to naled monitored for the 10 volunteers was 0.019 µg/kg BW per hour at 1 DAT. At this sampling interval, the mean inhalation exposure of the 10 volunteers to DDVP was also found to be roughly 1 to 2% of their dermal exposure to DDVP. At 3 and 7 DAT, the ratios of dermal to inhalation exposure decreased noticeably for both naled and DDVP; this is not inconceivable, however, since at these sampling intervals the residues are down to the detection limit which often yields a relatively unstable relation between dermal and inhalation exposure.

The reentry exposure rates listed in Table 7 and the resultant transfer rate were determined primarily for harvesters picking raisin (or wine) grapes. The rate values for table grape harvesters are expected to be lower, due to differences in canopy management of the vine involved. Unlike raisin or wine grape harvesters, table grape harvesters typically do not need to climb into and under the vines to pick grapes.

Available data (Dong *et al*., 1992; Welsh *et al*., 1993) to WH&S showed that the potential transfer rate and daily exposure would be higher, by about 2- to 10-fold, if the worker performed cane girdling, cane turning, or similar tasks, instead of picking and handling raisin or wine grapes. According to DuPont (Dong *et al*., 1992), the *potential* dermal transfer rate for grape girdling operation ranged from 18,000 to 93,000 µg/hr per µg/cm^2. In this reentry exposure assessment, the midrange of 50,000 was used instead. This slightly-rounded down midrange was preferred over the observed upper extreme, even for acute or short-term exposure, because there were certain sampling limitations (e.g., sensitivity issues as discussed above regarding the data presented in Table 7) inherent in the DFR data that generated those extreme transfer rates. Using a default clothing protection factor of 10 (Thongsinthusak *et al*., 1993a), the actual dermal transfer rate for this work group was reduced to 5,000.

Table 6. Average Levels of Naled and DDVP Residues on Grape Foliage Observed at Various Sampling Intervals[a,b]

Days Post-Application	Site 1 Naled	Site 1 DDVP	Site 2 Naled	Site 2 DDVP	Both Sites Naled	Both Sites DDVP
0	0.226	0.053	0.344	0.040	0.285	0.047
1	0.040	0.006	0.012	0.003	0.026	0.005
2	0.014	0.003	0.007	ND	0.011	0.003
3	ND	ND	0.009	ND	ND	ND
4	ND	ND	0.007	ND	ND	ND
5	0.003	ND	ND	ND	ND	ND

[a] from a study by Rosenheck and Cone (1994a); residue levels averaged over 3 replicates (in μg/cm^2) from the third and final application (at reapplication interval of 7 days) at two sites located in the same raisin vineyard in Fresno County; adjusted for recovery (ranging from 77.8 to 100.0%); ND ≡ not detectable (or below the minimum quantifiable limit of 2.5 ηg/cm^2).

[b] residue levels of DDVP, which is the initial metabolite of naled, are included here for calculation of exposure to total naled (based on the presumption, as stated in Section XI-5, that some hours would have to lapse before some naled residues could be transformed to DDVP in the atmosphere).

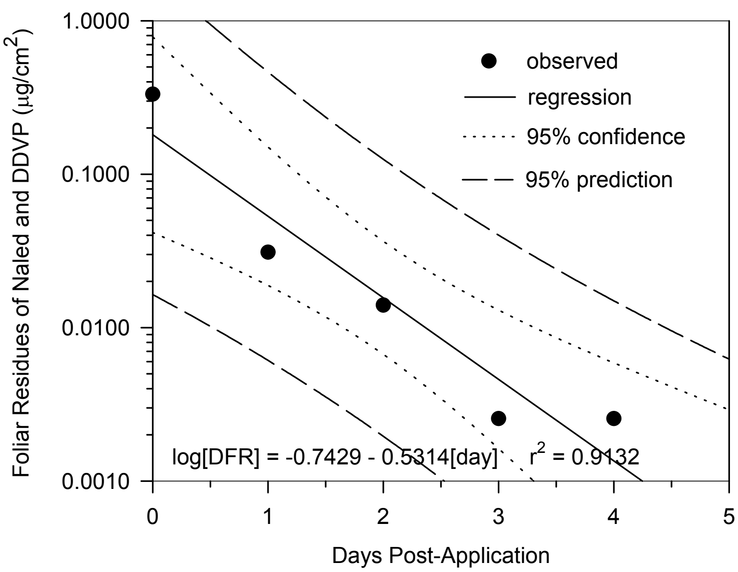


Figure 2. Dissipation of Naled and DDVP Dislodgeables on Grape Foliage (based on 0.9 lb naled/acre, after third application)

Table 7. Hourly Dermal and Inhalation Exposures to Naled and DDVP for Grape Harvesters

Reentry Interval[d]	Dermal[a] Naled	Dermal[a] DDVP	Inhalation[b] Naled	Inhalation[b] DDVP	Total[c] Naled	Total[c] DDVP
1	1.619	0.283	0.019	0.005	1.638	0.288
3	0.174	0.031	0.004	0.004	0.178	0.035
7	0.050	0.019	0.004	0.004	0.054	0.023

[a] arithmetic mean in µg/kg BW/hour, calculated from data in the reentry exposure study by Rosenheck and Cone (1994b) and adjusted for analytical recovery.

[b] arithmetic mean in µg/kg BW/hour, calculated from data in the reentry exposure study by Rosenheck and Cone (1994b) using a default respiration rate of 14 L/min (Thongsinthusak *et al*., 1993a) and adjusted for analytical recovery.

[c] in µg/kg BW/hour; representing (mean) value for both dermal and inhalation exposures combined.

[d] also referred to as days after treatment (DAT).

In addition to grapes, naled is used on numerous other crops for which certain cultural operations by field workers are likewise needed. For ease of reentry exposure assessment, these other crops were loosely divided into the following crop groups: Vegetable/row crops (including strawberries and field crops), tree fruit crops, greenhouse ornamentals, and cotton.

Naled is applied to tree crops during their dormant or delayed dormant period. Reentry exposure to naled thus need not be considered here for tree fruit harvesters. By nature of their work, the actual contact with foliage is expected to be very minimal for those field workers who, if any, must reenter treated orchards to verify treatment efficacy or perform similar activities.

For row and field crops such as beans, broccoli, strawberries, and the kind, the dermal transfer rate observed or used previously by WH&S were much lower than that for raisin or wine grapes noted above. WH&S used a dermal transfer rate of 3,500 – 4,000 previously to determine the reentry exposure to fenpropathrin for tomato and strawberry harvesters not wearing gloves (Dong, 1995). Based on this rate range, the dermal exposure to naled for vegetable or row crop harvesters at 1 DAT would be around 217 to 248 µg/hour. In this exposure extrapolation, the total naled and DDVP residues used for 1 DAT was 0.062 µg/cm^2, which is *twice* the sum of naled and DDVP presented in Table 6 because the maximum application rates for row or field crops are roughly *twice* that used for grapes in the two trials. For this vegetable harvester work group, the actual dermal transfer rate was considered to be close to the potential dermal transfer rate, in that much of the exposure is from the (bare) hands and the (uncovered) forearms.

WH&S previously also used a *potential* dermal transfer rate of approximately 11,000 for (ungloved) workers scouting in cotton fields treated with pesticides (Dong *et al*., 1991; Dong, 1993, 1994). Using a default clothing protection factor of 10 (Thongsinthusak *et al*., 1993a), the actual dermal transfer rate was reduced to 2,000. Since the maximum label rate for cotton is the same as that for grapes, the dermal exposure for cotton scouts at 1 DAT was estimated to be 62 μg/hour (= 2,000 x 0.031 μg/cm^2). There should be no significant reentry exposure to naled for cotton *harvesters* since the insecticide is not recommended for use on cotton after its first bolls have opened.

Since the *dissipation* kinetics for foliar dislodgeables observed on grapes are mainly a chemical- (rather than a crop-) specific phenomenon, these foliar residues were used here as surrogate for row crops, field crops, and cotton. In general, initial depositions of pesticide foliar dislodgeables are primarily based on application rate, since application methods are often carefully selected to cope with foliage density with the goal of producing an efficacious uniform concentration on leaf surfaces. Nonetheless, the naled (and DDVP) dislodgeables on greenhouse ornamental plants are expected to behave differently, *except initially*, in that they are constantly housed in an enclosed structure under regulated temperature.

The initial deposition of total naled and DDVP on greenhouse crops was estimated to be as high as 0.8 μg/cm^2, or approximately 2.5 times the total naled and DDVP presented in Table 6 above, since the maximum label rate for greenhouse crops is 1 fl oz per 10,000 cu ft, or 1.2 fl oz per 1,000 sq ft (of floor surface based on a height of 12 ft). The maximum label rate used for grapes in the two trials was 1 pint of naled AI per acre, or 0.37 fl oz per 1,000 sq ft (or about 3 times *less* than that for greenhouse ornamentals, based on floor surface). A 2.5-fold (not 3.0-fold) difference was used here because it was assumed that only up to 80% of the initial airborne residues inside the greenhouse would settle onto the floor.

WH&S previously used a dermal transfer rate of 7,000 for greenhouse harvesters not wearing gloves (Dong, 1994, 1996). This transfer rate, together with the initial deposition of 0.8 μg/cm^2, would yield an hourly dermal exposure of 5,600 μg per greenhouse worker. This hourly dermal exposure is considered to be applicable for greenhouse harvesters working at 1 DAT, since the dissipation of naled (and DDVP) dislodgeables may be slower in a confined area. As mentioned earlier, much of the airborne residues (from fumigation with hot plates, etc.) were assumed to settle quickly onto the treated greenhouse floor. Without any empirical data, it is not certain how much, if any, of the initial foliar residues in a greenhouse would dissipate by 1 DAT.

No consideration was made for residue build-up from previous application, since the reapplication interval for naled is typically 7 days or longer and the dissipation of naled DFR is very rapid. The initial deposition and the DFR levels at 1 DAT or thereafter were based on *observed* values, as those presented in Table 6. They were not calculated from the log-linear regression statistics presented in Figure 2, since the data points involved were considered to be statistically too few to constitute a powerful regression. Although there appears to be a high degree of correlation, the DFR for day 3 and day 4 that are presented in Figure 2 are artificial values assuming half of the detection limit. (Figure 2 was constructed and is presented here only for further reference as well as for completeness. Note that because of the relatively rapid dissipation of naled dislodgeables, more data points could result only if the foliar samples were collected more than once per day.)

XI-4. Agricultural Handlers and Other Users

For assessment of handler or user exposure, WH&S followed closely the scheme used by USEPA (1995a) in constructing the potential use scenarios. Based on the currently-registered labels, a total of 11 major exposure scenarios were identified for naled handlers or users. These use scenarios included: (1) mixing/loading naled liquid for aerial application, for groundboom application, for backpack spray, or for airblast spray; (2) applying the naled liquid mixture with aerial equipment; (3) applying with groundboom equipment; (4) applying with backpack equipment; (5) applying with airblast equipment (including using over-the-vine booms); (6) applying by evaporating liquid with a hot plate or pan; (7) flagging during aerial sprays; (8) mixing/loading/applying with thermal/cold fog generators, mist blowers, or ultra low volume equipment; (9) mixing/loading/applying with low pressure hand wands; (10) mixing/loading/applying with backpack sprayers; and (11) applying dog/cat collars.

Tables 8 and 9 below *summarize* the expected daily exposures to and the absorbed daily dosages of naled for the above agricultural handlers and non-production agricultural users, respectively. (In this exposure assessment document, the term production agricultural uses is synonymous with uses on agricultural crops.) Except where otherwise noted, such as for homeowners or non-production agricultural users, it was assumed that naled handlers would wear coveralls over long pants and a long-sleeved shirt, shoes plus socks, chemical-resistant gloves, goggles, head gear, and an approved respirator (as all of these were required by label). In California, a closed system is required for mixing/loading more than 1 gallon of liquid product per application that has Category I toxicity.

Full handler personal protective equipment (PPE) is also required for applicators putting naled into a disposable metal pan on an unheated hot plates (or presumably into pipes as well) in greenhouses. These hot plates must be activated by an automatic timer after all workers have vacated the greenhouse and the greenhouse is locked. Further assumptions used in the exposure calculation are footnoted in these two tables. Other than for mosquito control, no chemical-specific measurements of handler exposure to naled were available to WH&S. Accordingly, the exposures to naled calculated in the subsections below were necessarily based on surrogate data. For the most part, the surrogate data used were extracted from PHED (Pesticide Handlers Exposure Database, 1995).

All PHED subsets used in this exposure assessment contained grade A or B data with handlers all (except otherwise noted) wearing long pants, gloves, shoes plus socks, and a long-sleeved shirt. For agricultural applicators and flaggers, the dermal exposure rates calculated from these PHED subsets were adjusted for the 10-fold reduction from wearing coveralls and head gear/goggles (as required by label), which together cover over 80% of the total body surface. The rates of inhalation exposure for these agricultural applicators (except pilots) and (aerial) flaggers were also adjusted for the 10-fold reduction from wearing a respirator which is part of the required PPE. For mixer/loaders, the dermal exposure rates were further adjusted for the (rounded-down) 20-fold reduction from using both an apron and a closed system (as required by California regulations). The rates of inhalation exposure calculated from the PHED subsets for mixer/loaders were adjusted for the 20-fold reduction from using a closed system, but not for the 10-fold reduction from using a respirator (as such is not required to be worn by mixer/loaders using a closed system).

Mixer/Loaders. Mixing/loading naled liquid as a separate task was considered to be for production agricultural uses only. Otherwise, it was treated as part of the routine performed by the same individual (i.e., by an applicator) using hand-held equipment. The dermal exposure rate for total body surface from mixing/loading liquids, based on the arithmetic mean calculated from a PHED subset, was 23.5 μg/lb AI handled (after adjustment for using a closed system, etc., as noted earlier). The arithmetic mean inhalation exposure from PHED for mixing/loading liquid was much lower,

Table 8. Expected Daily Exposures and Dosages for Production Agricultural Uses of Naled[a]

Work Group/Task	Application Rate (lb AI/acre)[b]	Acres Treated[c]	Dermal Exposure[d]	Inhalation Exposure[e]	Total Exposure[f]	Absorbed Dosage[g]	Seasonal Dosage[h]	Annualized Dosage[i]
Mixer/Loaders - Aerial Spray	1.875	600	23.5	0.08	23.6	132.7	75.8	14.6
Mixer/Loaders - Groundboom[j]	1.875	100	23.5	0.08	23.6	22.1	12.7	2.5
Flaggers - Aerial Application	1.875	600	18.4	0.01	18.4	103.5	59.2	11.3
Applicators - Aerial Spray	1.875	600	1.5	0.02	1.5	8.47	4.8	0.9
Applicators - Airblast	3.750	40	89.9	0.63	90.5	68.1	38.8	7.4
Applicators - Groundboom	1.875	100	9.5	0.02	9.5	8.9	5.1	1.0
Applicators - Backpack	0.047[k]	40[l]	96,070[m]	26.47	96,096.5	903.3	516.1	99.0
Applicators - Hot Plate/Pan/Pipes	3.750[n]	< 5[n]	*minimal*[n]	*minimal*[n]	*minimal*[n]	*minimal*[n]	*minimal*[n]	*minimal*[n]

[a] assuming that workers wear coveralls over long pants, a long-sleeved shirt, shoes plus socks, chemical-resistant gloves, goggles, and a respirator, and that for mixing/loading, they would use a closed system in lieu of wearing a half-face respirator, all as per label requirements.
[b] maximum label rate in lb AI/acre, except otherwise noted.
[c] maximum acres treated per workday (*see* discussion in this section), except otherwise noted.
[d] in µg/lb AI handled; (arithmetic) mean exposure rate from PHED (*see* appendices) for total body surface with the specified clothing on, after adjustment for the default 90% protection from wearing coveralls and head gear (Thongsinthusak *et al*., 1993a) and for the default (rounded-down) 95% protection from using both a closed system and an apron during mixing/loading (Thongsinthusak and Ross, 1994).
[e] in µg/lb AI handled; (arithmetic) mean exposure rate from PHED (*see* appendices), based on a respiration rate of 14 L/min (Thongsinthusak *et al.*, 1993a) and after adjustment for the 20-fold reduction from using a closed system or for the 10-fold reduction from wearing a (half-face) respirator, where applicable.
[f] cumulative rate of dermal and inhalation exposures, in µg/lb AI handled.
[g] absorbed daily dosage (ADD), in µg/kg BW/day; based on an average adult male/female body weight (BW) of 70 kg and on a default dermal absorption of 35% and an inhalation uptake of 50% (*see* Section IX): ADD = [(total exposure rate) x (application rate) x (acreage or gallonage) x (absorption or uptake) x BW^{-1}].
[h] based on the use of two-thirds of the maximum acres treated or gallons used as a conservative usage average; and on the amortization factor of 0.86 for working 6 out of 7 days per week given that the time-to-effect for the subchronic effect at issue was 21 days (per e-mail from Lori Lim of the Medical Toxicology Branch dated 02/10/99 and *see* Section XIV) and that the annual exposure frequencies were all assumed to be 60 days (see footnote *i* below); seasonal dosage (µg/kg BW/day) = (2/3) x ADD x (6/7) = 57.14%(ADD).
[i] based on the use of two-thirds of the maximum acres treated or gallons used as a conservative usage average; and assuming an annual exposure frequency (AEF) of 60 days, which is noticeably more frequent than the default of 40 to 50 days used earlier (Dong *et al*., 1991; Dong, 1993, 1994) because of the relatively broader use for naled (on multiple crops); annualized dosage (µg/kg BW/day) = (2/3) x ADD x (AEF/365) = (0.001826) x (ADD) x (60) = 10.96%(ADD) .
[j] including those mixing/loading naled liquid for groundboom, backpack, or airblast sprays, since in general the task of mixing and loading is not specific to the (ground) application method used.
[k] in lb AI per gallon of spray dilution (*see* discussion in this section).
[l] maximum gallons of naled dilution to be sprayed per day (due to limited areas for treatment).
[m] due to lack of acceptable data, the PHED subset for this work group included only measurements that reflect total deposition (i.e., on workers without clothes); therefore, *additional* adjustment was made for applicators wearing normal work clothes (with a default protection factor of 90%).
[n] application rate was based on 1.2 fl oz per 1,000 sq ft (of 12 ft tall), and hence ~ 0.5 gallon/acre; and the maximum daily acres treated for greenhouse plants by a single applicator were previously assumed to be 1 or 2, but here the operator's task and exposure are minimal as he or she only has to put the naled product into a pan on an unheated hot plate (which will be activated by an automatic timer after all workers have been vacated the greenhouse).

Table 9. Expected Daily Exposures and Dosages for Non-Production Agricultural Uses of Naled[a]

Work Group/Task	Application Rate (lb AI/gallon)[b]	Gallons Used[c]	Dermal Exposure[d]	Inhalation Exposure[e]	Total Exposure[f]	Absorbed Dosage[g]	Seasonal Dosage[h]	Annualized Dosage[i]
				Homeowner Users				
Dog/Cat Collar[j]	—	—	—	—	—	222.3	22.2	1.22
Low Pressure Hand Wand	0.047	4	1,564.5	19.1	1,583.6	1.5	0.15	0.01
Backpack Sprayer	0.047	10	22,174.0	14.7	22,188.7	52.1	5.22	0.29
				Occupational Users				
Dog/Cat Collar (Veterinarians)[j]	—	—	—	—	—	44.5	25.4	4.87
Low Pressure Hand Wand	0.047	10	973.5	19.1	992.6	2.3	1.32	0.25
Backpack Sprayer	0.047	40	3,735.8	14.7	3,750.5	35.3	20.2	3.86
Sewage System Injection[k]	0.047	40	3,735.8	14.7	3,750.5	35.3	20.2	3.86
Mosquito Control (Aerial)[l]	—	—	—	—	—	< 60.0	< 34.2	< 6.58
Fogger/Mist Blower/ULV[m]	0.047	—	*no data*	*no data*	—	—	—	—

[a] assuming that homeowner users wear long pants, a long-sleeved shirt, shoes, and socks; and that occupational users wear normal work clothes *plus* coveralls and chemical-resistant gloves; both the homeowner user and occupational user groups were considered as mixer/loader/applicators (except when using the ready-to-use products or dog/cat collars).
[b] maximum label rate in lb AI per gallon of spray solution, except otherwise noted.
[c] maximum gallonage per workday (*see* discussion in this section), except otherwise noted.
[d] in µg/lb AI handled; (arithmetic) mean rate from PHED (*see* appendices) for total body surface with the specified clothing on (after adjustment for the 10-fold reduction from wearing coveralls or gloves, where applicable).
[e] in µg/lb AI handled; (arithmetic) mean rate from PHED (*see* appendices), based on a respiration rate of 14 L/min (Thongsinthusak *et al.*, 1993a).
[f] cumulative rate of dermal and inhalation exposures, in µg/lb AI handled.
[g] absorbed daily dosage (ADD), in µg/kg BW/day; based on an average adult male/female body weight (BW) of 70 kg and on a dermal absorption of 35% and an inhalation uptake of 50% (*see* Section IX): ADD = [(total exposure rate) x (application rate) x (gallonage or poundage) x (absorption or uptake) x BW^{-1}].
[h] where applicable (e.g., for workers but not for homeowners), based on the use of two-thirds of the maximum gallons or poundage used as a conservative usage average; and on the amortization factor of 0.86 for working 6 out of 7 days per week (as justified in footnote *h*, Table 8); seasonal dosage (µg/kg BW/day) = (2/3) x ADD x (6/7) for workers, and = (2/20) x (ADD) for homeowner users due to difference in the annual exposure frequencies assumed in footnote *i* below).
[i] where applicable (e.g., for workers but not for homeowners), based on the use of two-thirds of the maximum gallons or pounds used as a conservative usage average; and assuming that workers would be handling the insecticide 60 days per year as would agricultural use applicators; and that for homeowners, the exposure frequency would be 2 days (from 2 applications) per year; annualized dosage (µg/kg BW/day) = (2/3) ADD x (60/365) for workers, and = (2/365) x (ADD) for homeowners [*for completeness only*, otherwise not likely to be of concern due to the very low exposure frequency involved].
[j] based on the release rate estimated by Haskell (1995); veterinarians (*with* gloves) and homeowners (*without* gloves and hence receiving comparatively higher exposure) are expected to treat (up to) 10 and 5 animals per day, respectively (*see* text discussion).
[k] based on the dermal and inhalation rates estimated for applying with backpack sprayers (*see* text discussion for justification).
[l] based on the Delaware study by Kutz and Strassman (1977), as discussed in the text in this section.
[m] ULV ≡ ultra low volume type equipment; it was grouped with mist blower and thermal/cold fog generator partly due to their similar use in wide area.

only 0.08 μg/lb AI (after adjustment for using a closed system). For further reference, the exposure statistics from the two PHED subsets are attached to the end of this document as Appendices 1A and 1B. The maximum acres treated per day for aerial and ground applications were assumed to be, respectively, 600 and 100. The maximum usage was assumed to be the equivalent of 100 acres for a worker mixing/loading naled liquid for (multiple) backpack or airblast type application(s), the same maximum usage as assumed for groundboom mixer/loaders. For backpack and airblast applicators, however, the maximum usage was assumed to be, respectively, 40 gallons (due to limited or hard-to reach areas for treatment) and 40 acres per person per day.

The above *interim* usage defaults, while comparable to the maximum values adopted by USEPA (1995a) and the upper extremes observed by Valent USA (1995b), are not unrealistic. It was found that 15 of the 97 aerial applicators (replicates) in PHED treated more than 600 acres per monitoring duration (presumably per application or per workday); the highest (total daily) usage observed in this group of applicators in PHED was 1,061 acres. Of the 200 groundboom applicators (replicates) included in PHED, 8 individuals treated more than 100 acres per monitoring duration; the highest usage observed in this group in PHED was 348 acres. Among the 123 airblast applicators (or replicates) in PHED, 8 individuals treated more than 20 acres per monitoring duration; the highest usage observed in this group in PHED was 37 acres.

In addition, the PUR (pesticide use report) data showed that in Kings County during the single month of June, 1995, naled was sprayed to an average of 448 acres of cotton per aerial application. In Fresno in May, 1995 alone, naled was sprayed to an average of 476 acres of safflower per aerial application. And in Kings County again, naled was reportedly sprayed to an average of 111 acres of cotton per ground application during July, 1995 alone. The data also showed that for oranges that are usually sprayed using airblast equipment, an average of 44 acres in Kern County was treated per application during the month of May, 1996.

Although these pesticide use data reflect greatly the maximum acres treated per aerial or ground application, the daily maximum acreage treated also depends on the number of applicators involved per application and on the number of applications that can be made in a workday (of 6 or 7 actual application hours). With groundboom application equipment, an operator typically can treat no more than 10 to 15 acres of crop per hour. An aircraft pilot (i.e., an aerial applicator), on the other hand, can typically spray up to 100 acres of crop per hour.

The maximum label rates for aerial or ground application and for airblast spray are 1.875 and 3.75 lb AI per acre, respectively. That for backpack or other hand held spray is 4.69×10^{-2} lb AI per gallon of water or spray dilution. The expected daily exposures (and hence the absorbed daily dosages as well) calculated from these assumed usages and rates are summarized in Table 8.

Flaggers. The dermal exposure rate for total body surface of a flagger during aerial sprays was calculated to be 18.4 μg/lb AI handled (after adjustment for the required additional PPE protection). This exposure rate again was an arithmetic mean calculated from a subset extracted from PHED, which is attached as Appendix 2A. The arithmetic mean rate of inhalation exposure calculated from the same sample group, which is attached as Appendix 2B, was 0.01 μg/lb AI (after adjustment for additional PPE protection). The maximum acres treated per day were also assumed to be 600 for aerial sprays.

Applicators. As expected, the daily exposure of applicators to naled varies greatly depending upon the application method or equipment used. For production agricultural uses, the rates of dermal and inhalation exposures of naled applicators were based on the arithmetic means calculated from PHED for use with various application methods or equipment. The daily exposures and absorbed dosages calculated for these applicators are summarized in Table 8 above. Also included in Table 8 are rates of dermal and inhalation exposures that were obtained from various subsets extracted from PHED. These subsets are appended to this assessment document for further reference (as Appendices 3A through 6A for dermal exposure, and 3B through 6B for inhalation exposure).

As shown in Table 8, the highest average dermal and inhalation exposures are, respectively, 96.1 and 0.03 mg per pound of naled AI applied with a backpack sprayer (after adjustment for required work clothing and PPE). These findings are not surprising, in that backpack operators tend to walk towards where they are directing their spray and walk past foliage that has been treated (Matthews, 1992). USEPA also included this task group in their calculation of occupational exposure to naled (1995a). However, according to Valent USA (1995b), backpack type equipment is seldom used during treatment of agricultural crops. And if used, normally it would be used by a grower who would mix, load, and apply the pesticide himself (or herself). Treatments of cotton, row crops, or field crops are made primarily with aerial or groundboom equipment. Grapes and fruit or nut trees, on the other hand, are typically treated via airblast.

No PHED or other types of data are available for use to estimate the exposure of applicators putting naled on unheated hot plates/pans or on pipes in greenhouses. According to the Dibrom 8 Emulsive product label, these applicators are required to wear full handler PPE. Exposure to naled for these workers is considered to be minimal, however, in that the hot plate (or pipe) must be activated by an automatic timer after all workers have vacated the greenhouse and the greenhouse is locked for at least 3 hours. At the application rate of 0.5 gallon of the product per acre of greenhouse crop, or 1.2 fl oz per 1,000 sq ft (for a 12 ft tall greenhouse), the contact with the naled active ingredient per day by a single operator is expected to be minimal and of short duration.

Non-Production Agricultural Use Operators. For this group of users, the daily exposures and absorbed dosages that could be estimated from available rates are summarized in Table 9 above. As expected, there are no exposure data available for many of these operators. The exposure rates that are available and were used in the exposure calculations are discussed below. In most cases, non-production agricultural use operators were further subdivided into homeowners and commercial applicators. In accordance with USEPA (1995a), homeowner users in this exposure assessment were assumed to wear long pants and a *long*-sleeved shirt (plus shoes and socks) *without* gloves *nor* coveralls while handling or applying the insecticide. (WH&S concurred that homeowner users would wear a long-sleeved shirt in that naled is not as common a pesticide product as, e.g., diazinon.) As footnoted in Table 9, commercial operators and homeowner users were assumed to handle the insecticide 60 days and 2 days per year, respectively. The exposure duration of homeowner users was also expected to be less, compared to that of commercial operators who were supposed to be clothed additionally with coveralls and gloves (as per label requirements).

Flea/Tick Collars. Naled is available in the form of an impregnated collar for use by homeowners and veterinarians to control ticks and fleas present on dogs or cats. This pet collar typically weighs less than 1 oz and contains between 7% and 15% naled AI (by weight). Exposure to naled from placing the collar around the neck of the animal is expected to be minimal due in part to the small dose of AI (< 4 gm) being handled. There are also data showing that a maximum release rate of an AI *over a 90-day period* is likely not to exceed 20% of the chemical initially present in a collar (Haskell, 1995). If the pet handler experienced the maximum released dose of naled available while placing the collar on the animal with *bare* hands, and treated 10 pets per day, then the absorbed daily dosage (ADD) that he or she would receive, prior to adjustment for glove protection, would be 634.9 μg/kg BW/day [= (4 gm/animal) x (20% as amount released) x (10 animals/day) x (90 days)$^{-1}$ x (35% dermal absorption) x (70 kg BW)$^{-1}$] for a veterinarian with an average body weight (BW) of 70 kg. For homeowners (without gloves), the ADD would be 2 times *less*, or 317.5μg/kg BW/day, since even those who love pets very much are not expected to treat more than 5 animals per day.

<u>*Mosquito Control Crew*</u>. The Delaware study by Kutz and Strassman (1977), which was discussed earlier regarding the exposure for non-user residents, also monitored the urinary levels of DMP for workers of the mosquito control crew and the aircraft pilot. The results of the urine analysis indicated that the arithmetic mean of the DMP level from this work group was approximately 3 times the mean level seen in the 56 residents who stayed outdoors at the time of application. The maximum ADD for these workers hence is expected to be less than 60 μg/kg BW, or not to exceed 3 times that estimated for the residents.

<u>*Thermal Fog Generator/Mist Blower/ULV*</u>. When used with a thermal fog generator, pesticides like the Dibrom concentrate usually will be dissolved in a petroleum solvent and injected into a hot gas to be vaporized. A dense fog is hence formed by condensation of the petroleum when the pesticide vapor is discharged into the atmosphere. Fogging is particularly useful for the control of flying insects not only through their contact with the droplets, but also by the fumigant effect of the volatile pesticide involved. Adequate engineering controls and PPE must be provided to avoid inhalation of the fog, since the smallest droplets are not trapped in the nasal area but may be carried into the lungs.

There were no PHED or other data available to WH&S for estimation of the exposure to naled from application with thermal/cold fog generators, mist blowers, or ultra low volume (ULV) equipment in *wide* areas. A review of the literature indicated that there was one related study available by Giles *et al*. (1995), in which fogger application of pesticide in *greenhouses* was investigated. In that study, the air concentration of permethrin was monitored for 16 hours following the spray by a *fully*-clothed (from head and face down) applicator using a thermal fogger. Dermal exposure was not monitored.

<u>*Low-Pressure Hand Wand*</u>. Users who mix/load and apply naled at non-agricultural (production) sites with low pressure hand wands are typically commercial applicators. The two PHED subsets in Appendices 7A and 7B show that the dermal and inhalation exposures for these workers are 973.5 (after adjustment for wearing coveralls and gloves, which homeowners were not expected to wear) and 19.1 μg/lb AI handled, respectively. In accordance with USEPA's scenario scheme (1995a), in the exposure assessment here individuals are not expected to spray naled with a *high-pressure hand wand* since other specific application methods, such as via thermal or cold fog generators, backpack sprayers, and mist blower, are suggested as a more effective alternative.

<u>*Backpack/Sewage System Injection*</u>. Exposure from applying with backpack sprayers was derived from PHED and used as a surrogate for exposure received from treatment of sewage system via injection. These surrogate data are summarized in Appendices 8A and 8B (after adjustment for

wearing coveralls and gloves, which homeowners were expected not to wear). There were no data on exposure for applicators treating sewage systems with injection type equipment. Exposure for backpack (mixer/loader)applicators was used as a surrogate here partly because such would over, rather than under, predict the exposure received from treatment of sewage system via injection, and partly due to the fact that sewage injection equipment can also be considered loosely as the hand-held or backpack type. The exposure for sewage injection applicators is likely to be overestimated with this backpack surrogate because as mentioned earlier, backpack operators tend to walk towards where they are directing their spray and walk past foliage that has been treated (Matthews, 1992). Another justification, though not as direct, for the lower exposure expected from sewer injection treatment was given earlier by WH&S (Donahue, 1993) when it commented on the use of metam-sodium for treating sewer systems. As pointed out by Valent USA (1995b), the uses/sites where backpack spraying is important for naled include: (1) ornamental shade trees and shrubs (not for use by homeowners); and (2) fruit fly control in and around food processing plants, cull piles, refuse areas, and cider mills. It is important to note that here the exposure rate from backpack spraying is supposed to be lower for non-production agricultural uses than for production agricultural uses. Such an expectation was based on the assumption that for non-production agricultural uses, the operator is not expected to work within a confined area as much, or to walk past *dense* foliage that has been treated.

XI-5. Exposure Appraisal

In using the absorbed dosages calculated in this exposure assessment, it is important to note that there were uncertainties built into the process that might not be immediately apparent to the risk assessor or the risk manager. Many of these uncertainties tend to overestimate the exposures involved, but are typically hidden and therefore seldom acknowledged. Below is a brief account of the uncertainties associated with the factors used here that tend to have a critical impact on the exposures calculated.

Data on Inhalation/Dermal Exposures. As presented earlier (*see* Section XI-1), only the *highest* air level of naled measured over a 24-hour period in the 1991 Tulare study was used to calculate the daily inhalation exposure to naled from ambient air. The calculated daily inhalation exposure from ambient air would be much lower if the (outdoor) ambient air levels used were averaged over the 16 daily samples (from each monitoring station), and not based on the highest observed over the 16 sampling days. It is of note that the value of the collocated duplicate of the highest observed (0.08 $\mu g/m^3$) for naled (for that same day at the same monitoring station) was only 0.04 $\mu g/m^3$. Airborne naled and DDVP residues were found to be below the LOQ (limit of quantitation) in over 70% of the 16 daily samples (collected from May 9 through June 6, 1991). Yet despite its overrepresentation (especially in reference to subchronic or chronic exposures), the use of the highest ambient air level was not considered to be totally inappropriate in that the 1991 usage of naled in Tulare was only the second highest by county (*see* Section XI-1). Nor was the 1991 naled usage in all counties the highest by year, as evident from the usage data presented in Table 2.

The dermal exposure rates derived from surrogate studies included in PHED were based on passive patch dosimetry data. Less accurate estimates could result from extrapolating the patch residues observed in limited areas to a much greater body surface area, since this approach would magnify any errors inherent or introduced in the measurement. These passive patch data in theory would hence likely over- or under-estimate the actual dermal dose substantially when compared to whole body dosimetry data. However, in practice patch data tend to overestimate, rather than underestimate, the actual dermal dose (e.g., Maddy *et al*., 1989). One likely explanation for this overestimation tendency is that the areas under the arms and between the legs are shielded by the appendage and hence would have lower exposure than the unshielded areas that were monitored with a patch.

The exposure rates presented in Tables 8 and 9 were, for the most part, based on arithmetic means calculated by PHED or directly from observed values. Upper-end values were not used for the exposure rates in question partly because the values assumed for the application rate and for the daily usage were already at their (practical) maximum. Because of the great variability inherent in the PHED data, the upper-end values would be unrealistically high to use if they were to be derived from the confidence limits (C.I.) provided on the arithmetic mean. Similarly, the C.I. (and other statistics) presented in the Delaware biomonitoring study (Kutz and Strassman, 1977) also would not allow the extrapolation of a reliable distribution that can be used to estimate the upper percentiles.

The PHED subsets appended to this document clearly showed that the 95% C.I. on the arithmetic mean for dermal exposure included negative values. Therefore, to use the upper 95% C.I. from such a statistical interval is meaningless. To have a negative value for the mean exposure rate (even though physically impossible), the sample set must contain two clusters of exposure rates representing two extremes that are very far apart, with the lower extreme group dominating. Arithmetic means calculated from lognormal distributions are often seen to be at the 75th percentile or thereabouts. For the type of lognormal distribution that has the lower extreme group so dominating as described above, the arithmetic mean would be at a higher percentile, like around the 85th or above. On the other hand, the mean plus the upper 90% or 95% C.I. from this type of distribution would yield an upper extreme that is materially unreal.

Although PHED could not provide realistic upper-end values for the exposure rates, it is important to note that these rates were expressed as per lb AI handled. If the total amount of AI handled per day is at its upper extreme, as in the case here where reasonable maximum usage defaults were used (*see* Section XI-4 for daily acreages and application rates), then the actual daily exposure is likely to be overestimated even if an *average* exposure *rate* is used. Also, despite the fact that measured exposures could vary over 100- or 1,000-fold, by the time the average or midpoint is used, the difference between the highest and the midpoint is merely two-fold.

Dermal *vs*. Oral Plasma Levels. Dosage is expressed as a single *static* value both in worker exposure and animal toxicology studies. The rate of dermal absorption is often seen or expected to be lower than the rate of oral absorption in animals used for toxicology testing. It is very likely the case that adverse effects occur only when plasma levels in the target organ exceed a critical level (*see* Ross *et al*., 2000); yet dermal acquisition takes place over the entire workday. Since dermal acquisition is slower and less than that by the oral route, plasma levels for the same total absorbed dosage thus will not be nearly as high from a dermal versus an oral exposure. In other words, a dermal dose acquired over the entire workday produces peak plasma levels much lower than those from the bolus oral feeding dosage acquired by animals in minutes to less than an hour. Because the adverse effect used for risk assessment is dependent on the concentration at the site(s) of action (which generally correlates with plasma level), treating an 8-hour dermal acquisition as though it were a bolus (i.e., summing the entire dermal dose) is so conservative that it outweighs any perceived source of dose underestimation.

The above argument applies to naled as well, even though its adverse effects might in fact be considered (totally) irreversible by some (e.g., regulatory) standards. First, there is some indication that reactivation of inhibited dimethyl phosphate cholinesterase would occur spontaneously, at approximately 1% per hour (Fan, 1998). Second, it is important to note that whether originated from dermal or oral exposure, plasma level reflects how much a chemical under study is available (or circulating) in the body system and is a function of dose. To simplify the points made, the argument may be summarized in quantitative terms as follows:

$$[\Sigma^{8}\ \{1 \text{ unit (dermal)}\}] \leq [8 \text{ units (dermal)}] < [8 \text{ units (oral)}].$$

Where an *ir*reversible effect is involved, the 8-hour incremental effect from the first term or exposure scenario is likely to be close to, and not less than, the bolus effect from the second term. However, the *re*versible effect from the first term certainly would be less than that from the second term, given the reasons stated above regarding the slower absorption and acquisition of dermal dose. On the other hand, the third term (the oral exposure scenario) typically would yield a much higher peak plasma level or a much greater effect, whether irreversible or not, than would either of the first two dermal exposure scenarios.

The study by Auton *et al*. (1993) showed that the peak plasma level from oral dosing of fluazifop-butyl, after normalization for the amount absorbed, could be as high as 8 times the peak level from dermal dosing. It was found that the lower the absorbed dose, the more pronounced the difference became. This difference is particularly pertinent when comparing the doses used in a toxicology study versus those to which a human would be exposed. Lower urinary metabolite concentrations (i.e., an indication of lower peak plasma concentration) have been seen with dermally applied pesticides when compared with the urinary metabolite concentrations observed following oral dosing (Krieger *et al*., 1991). The study by Carmichael *et al*. (1989) on triclopyr and that by Nolan *et al*. (1984) on chlorpyrifos are two additional cases among several others supporting the findings by Auton *et al*. (1993).

In the aforementioned study by Nolan *et al*. (1984), for example, peak blood concentrations of the 3,5,6-TCP metabolite were 0.93 and 0.063 μg/ml following, respectively, a 0.5 mg/kg oral and later a 5.0 mg/kg dermal administration of chlorpyrifos in the same group of human volunteers. Oral absorption (especially in humans) is not available for most pesticides (including fluazifop-butyl, chlorpyrifos, and triclopyr). In this example, even if the oral to dermal absorption of chlorpyrifos had a 100:1 margin in humans, the normalized observed peak blood level of 3,5,6-TCP from the oral absorbed dose would still be 50% higher than the normalized observed peak level from the dermal absorbed dose. If the margin for oral to dermal absorption of chlorpyrifos were lowered to 50:1, then the normalized observed peak blood level of 3,5,6-TCP from the oral absorbed dose would be three times the normalized peak level from the dermal absorbed dose. If the margin were lowered further to 25:1, then the difference in the normalized peak blood level would be increased (from three-) to six-fold. Using the margin of 25:1 for oral to dermal absorption, the above study by Carmichael *et al*. (1989) showed that the normalized human peak plasma level of triclopyr from oral dosing was 5 times the normalized level from dermal dosing. There is good indication (Haskell *et al*., 1998; Thongsinthusak 1996) that the ratio of oral to dermal absorption is well below 25:1 for both compounds. Further discussion and illustration on these numerical comparisons can be found in the work by Ross *et al*. (2000).

Partial *vs*. Full Workday Exposure Monitoring. Ross *et al*. (2000) also suggested that another source of dose overestimation could come from monitoring worker exposure for less than a full day's work. There is evidence (Spencer *et al*. 1995) showing that if an estimate of full day exposure (12 bins picked) were extrapolated from 1/3 day (4 bins picked), the exposure would be overestimated by more than 50 to 80% and if from 1/2 day (6 bins picked), 20 to 40%. Shorter monitoring periods are often encouraged for economic reasons in that they allow an investigator to obtain two or more observations per worker per day of monitoring. There is evidence that hand residues remain virtually constant after exposure for the first couple of hours, indicating that they reach the saturation point rather quickly. Thus, summing hand washes taken throughout the work (or exposure) day may grossly overestimate actual dose. This same principle is operative for studies involving exposure to pesticide handlers. The overestimation from partial day monitoring is not limited to data from serial hand washes, but also extended to those from passive patches, including those in PHED, from which the data were used to calculate many of the absorbed daily dosages presented in Tables 8 and 9.

Dermal Absorption. The dermal absorption value of 35% used throughout this exposure assessment was likely to have overestimated the actual absorbed dermal doses by as much as 2- to 3-fold. The mean human dermal absorption for 13 pesticides from several different chemical classes, as compiled by Thongsinthusak *et al*. (1993b), was 19%. When the pesticides in this 1993 compilation were limited to organophosphates (n = 6, not including DDVP), the mean and the highest were 10% and 16%, respectively. It is of note that in many cases, a substantial difference would still occur even if *chemical-specific* data from *animal* studies were available and used. According to a review on a handful compounds tested and available, the rat was found to overestimate human dermal absorption by two- to ten-fold (Wester and Maibach, 1993; Ross *et al*., 2000).

Exposure To DDVP. The concern (Fan, 1998) over the apparently higher acute and (sub)chronic toxicity and effects of DDVP (dichlorvos) is not warranted here in terms of the risk (and hence the exposure) assessment for naled, at least not based upon the data on hand. Although metabolic data showed that naled initially converts to DDVP in animals (*see* Section X), the toxicity as well as the potency of DDVP (or of any other metabolites of naled) would manifest in the animal data used to determine the adverse effects for naled. For example, if there were no (increased) tumors observed when certain doses of naled were administered in a group of rats for two years, but this were not the case when certain doses of DDVP were given, then the only logical interpretation is that DDVP as an *in vivo* metabolite of naled is not in the form that can cause tumors in rats. On the other hand, if DDVP as an *in vivo* metabolite could cause different acute and (sub)chronic effects or result in higher toxicity of the same effects caused by naled, such should manifest in the health effects data for *naled* and hence would be picked up accordingly during the hazard identification process.

One might argue that the airborne or surface DDVP *residues* that enter into the human body could behave differently compared to those available *in vivo*, as some adverse effects are indeed highly tissue- or route-specific. However, as indicated in Table 7, exposure to the airborne DDVP residues of 0.005 μg/kg/hour at day 1 (post application) was minimal (equivalent to an ADD of 0.04 to 0.05 μg/kg/day) for grape harvesters or other field workers. Table 7 also shows that the ratio of naled residues on grape foliage to those of DDVP was 4:1 or greater. However, this ratio is actually around 19:1 in terms of *absorbed* dosage, since the default dermal absorption of 35% was used in this exposure assessment when the percutaneous absorption for DDVP was in fact 11% (Valent USA, 1995a) to 13% (Fong and Formoli, 1993).

In terms of the exposure to DDVP residues in the atmosphere or on foliage that are available directly from a naled application, the absorbed dosages for the various field worker groups hence would be about one-twentieth (i.e., 5 to 6%) of those presented in Table 5. On the other hand, to err on the side of overestimation, the dosages in Table 5 for reentry exposure by field workers were calculated for naled and DDVP combined. While naled is easily degraded by sunlight, it will lose its bromide to form DDVP normally only in the presence of metals and reducing agents. Furthermore, it takes time for this debromination process to initiate or to complete. Thus, potential exposure to airborne or foliar residues of DDVP (from conversion of naled by debromination) is expected to be very minimal for commercial applicators and homeowner users. For homeowner users, like for commercial handlers, the daily exposures were in one form or another *already* based on the *total* amount of naled AI *applied* or *handled*. In addition, commercial handlers are expected to leave the treatment site shortly once application has been made.

When DDVP residues were added to naled to calculate the dosages for field workers, it was based on the premise that a field worker could be exposed to the naled residues before the foliar residues had time to lose their bromide molecules to form DDVP. That is, it was based on the very conservative presumption that, if the foliar samples were collected an hour or so earlier, some of the DDVP residues could still be in the parent form (i.e., naled). Another good reason for adding naled and DDVP residues together for field workers is when both compounds would or could induce the same adverse effects. It is important to note here that although DDVP is said to be 5 times potent or toxic (Fan, 1998), its dermal absorption is 3 or 4 times less than that of naled. Because at most only a fraction of the (observed) DDVP residues is expected to be still in the parent form, the addition of DDVP to naled was not adjusted for their difference in molar weight.

The daily dosages from ambient air calculated for children and adults in Section XI-1 were for inhalation exposure to naled alone. There was no evidence that the airborne DDVP residues as measured and reported were totally a breakdown product of the naled residues at issue. Otherwise, for children and adult residents exposed to *total* naled in ambient air, the daily dosages at most would be 1.3 times those calculated in Section XI-1. In the present exposure assessment, such a small (uncertain or unlikely) increase was considered insignificant and hence an adjustment was not made in the final calculations in Section XI-1, especially in light of the fact that the highest air level of naled was used already. The above suggestion of using a factor of 1.3 was based on the observation that the 24-hour air level of DDVP measured on the same day at the same site (where the highest naled level of 0.082 $\mu g/m^3$ was observed) was 0.025 $\mu g/m^3$. As indicated in Table 7, a similar residue ratio was observed at the site on day 1 following a naled application to grapes. This ratio suggests that where the dosages and adverse effects of DDVP must be dealt with separately, one-third of the naled dosages calculated in Section XI-1 could be used as the daily dosages expected for exposure of children and residents to DDVP in ambient air.

As shown in Table 4, for bystanders and non-user residents directly subject to aerial sprays (and release from pet collars or the like), their *un*absorbed daily doses of naled back-calculated from the biomonitoring data were less than 60 µg/person. According to Table 7, no more than 20% of the airborne and surface naled residues would be transformed to DDVP in the atmosphere (vs. *in vivo*). That is, if the dosages and toxicity of DDVP must be dealt with separately, then one-fifth of the dosages presented in Table 4 could be used as the dosages of DDVP for bystanders and non-user residents following a naled application.

In short, if the dosages and adverse effects of DDVP from a naled application must be dealt with separately, then the absorbed dosages of DDVP for the various exposure scenarios can be estimated as follows:

> For *ambient air*, use one-third of the dosages calculated for naled in Section XI-1.
>
> For *bystanders and non-user residents directly subject to aerial sprays, release from pet collars, and the like*, use 20% of the dosages listed in Table 4.
>
> For *field workers*, use 5% of those listed in Table 5.
>
> *Handlers/users* are not expected to be exposed to DDVP as a breakdown product in the atmosphere following a naled application.

Children from Pet Collars. It was justified in Section XI-2 (Residents/Bystanders) that exposure of children to naled from pet collars would be minimal, as parents are not supposed to let their children near or play with pets whose body is found to have fleas or ticks. The product labels also specify explicitly that children are not allowed to play with these collars. Even if children are not stopped from playing with their pets wearing a collar impregnated with naled, they are not expected to pet the animal around the collar area for too long. This expectation of minimal exposure is also consistent with the findings of the exposure assessment performed earlier for DDVP (Fong and Formoli, 1993), in which acute and chronic exposure of children to pet collars impregnated with DDVP was concluded to be insignificant. Nonetheless, more recent regulatory interpretation *may* eventually invalidate parental guidance as a feasible or an enforceable mitigation measure. In that case, the exposure in question should be calculated using either some chemical/use-specific data to be made available, or some conservative assumptions adopted (or to be adopted) by regulatory agencies. If children are indeed expected to play with or grab the pet collar for *long enough time*, which is not a *default* assumption supported in this exposure assessment, then their exposure to naled from such an activity could be comparable to that calculated in Table 9 for adult residential users handling pet collars in homes. It is important to note that even if the release is triggered primarily through hand contact with the pet collar, not *all* that is dislodgeable (i.e., releasable) from the collar will become transferable onto the child's hand or skin.

Other Factors. In calculating the absorbed dosage in this exposure assessment, the average body weight assumed for workers was 70 kg. The use of this default value might have overestimated slightly the naled dosages for several work groups whose exposure rates were calculated from PHED. The exposure rates calculated from PHED were based on studies in which the volunteers were primarily male workers. The average body weight for male adults is approximately 10% higher than the average of 70 kg assumed here for male/female adults (USEPA, 1997; Thongsinthusak *et al*, 1993a). Also, the total body surface area used for the PHED rate estimates was 21,760 cm^2, which is about 15% higher than that later re-calculated by USEPA (1997) for an average male adult of 78 kg. Another conservatism made with the PHED estimates is the use of 14 L/min as the average breathing rate for light work, when the default value is 11 L/min for average male/female adults engaged in most pesticide handling tasks. In using the higher respiration rate, it was assumed that this physiological parameter is related more to the type of activity involved than to an adult's sex or body size. Also, as noted earlier, the volunteers in the PHED studies were primarily male workers.

The use of 260 days for vegetable crop harvesters was a conservative approach, given that it is very unlikely for a worker to migrate from crop to crop or field to field, or for those crops all to be treated with naled. However, due to the lack of more specific data, such a conservative default was used, and was based on the assumption that these workers could harvest naled-treated crops 6 days a week for as many as 10 months in a year. A comparable annual exposure frequency (of 227 days) was also used by Thongsinthusak *et al*. (1996) for broccoli harvesters exposed to chlorothalonil. As indicated in Table 3, the usage of naled on broccoli remained in the top five crops between 1994 and 1996. The Department's use data showed that in Monterey County, naled was applied to broccoli every month between 1994 and 1996. The data also showed that in the same county, the insecticide was applied to celery nine months in 1994 and another nine months in 1995.

For flea and tick killer products, veterinarians and homeowners were assumed to be exposed to 100% of the amount (i.e., of the 20%) of naled released from the pet collar. As stated above for exposure of children from pet collars, the reality is that even if the release is triggered primarily through hand contact with the pet collar, not *all* that is dislodgeable (i.e., releasable) from the collar will become transferable onto the human hand or skin. Nor will all that is transferable be sticky enough to remain long enough on the skin or clothes. There are, nonetheless, no empirical data available to quantify the lower transfer rate. Although transferability studies following pet application have been conducted by USEPA's Office of Research and Development, they are not currently available.

XII. REFERENCES

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XIII. APPENDICES

Appendix 1A: Subset from PHED for Dermal Exposure of Agricultural Mixer/Loaders (Prior to Adjustment for Using a Closed System or Additional PPE)

Appendix 1B: Subset from PHED for Inhalation Exposure of Agricultural Mixer/Loaders (Prior to Adjustment for Using a Closed System or Using Additional PPE)

Appendix 2A: Subset from PHED for Dermal Exposure of Agricultural Flaggers During Aerial Spray (Prior to Adjustment for Using Additional PPE)

Appendix 2B: Subset from PHED for Inhalation Exposure of Agricultural Flaggers During Aerial Spray (Prior to Adjustment for Using Additional PPE)

Appendix 3A: Subset from PHED for Dermal Exposure of Agricultural Applicators Using Aerial Spray Equipment (Prior to Adjustment for Using Additional PPE)

Appendix 3B: Subset from PHED for Inhalation Exposure of Agricultural Applicators Using Aerial Spray Equipment (Prior to Adjustment for Using Additional PPE)

Appendix 4A: Subset from PHED for Dermal Exposure of Agricultural Applicators Using Airblast Equipment (Prior to Adjustment for Using Additional PPE)

Appendix 4B: Subset from PHED for Inhalation Exposure of Agricultural Applicators Using Airblast Equipment (Prior to Adjustment for Using Additional PPE)

Appendix 5A: Subset from PHED for Dermal Exposure of Agricultural Applicators Using Groundboom Equipment (Prior to Adjustment for Using Additional PPE)

Appendix 5B: Subset from PHED for Inhalation Exposure of Agricultural Applicators Using Groundboom Equipment (Prior to Adjustment for Using Additional PPE)

Appendix 6A: Subset from PHED for Dermal Exposure of Agricultural Applicators Using Backpack Sprayers (Prior to Adjustment for Using Additional PPE)

Appendix 6B: Subset from PHED for Inhalation Exposure of Agricultural Applicators Using Backpack Sprayers (Prior to Adjustment for Using Additional PPE)

Appendix 7A: Subset from PHED for Dermal Exposure of Mixer/Loader/Applicators Using Low Pressure Hand Wands (Prior to Adjustment for Using Additional PPE)

Appendix 7B: Subset from PHED for Inhalation Exposure of Mixer/Loader/Applicators Using Low Pressure Hand Wands (Prior to Adjustment for Using Additional PPE)

Appendix 8A: Subset from PHED for Dermal Exposure of Mixer/Loader/Applicators Using Backpack Sprayers (Prior to Adjustment for Using Additional PPE)

Appendix 8B: Subset from PHED for Inhalation Exposure of Mixer/Loader/Applicators Using Backpack Sprayers (Prior to Adjustment for Using Additional PPE)

(These PHED Attachments are neither photocopies nor, due to system incompatibility, from imported files; they were reproduced using an imperfect scanner and hence necessarily with some touch-up work. Nonetheless, the accuracy of their contents had been checked and assured to the extent possible.)

APPENDIX 1A
(Mixer/Loaders)

Name: NALED1A.MLOD   Subset Specifications for NALED1A.MLOD

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Mixing Procedures Equal to 1 and
With Outdoor Equal to "X" and
With Dermal Grade Uncovered Equal to "A" "B"
Subset originated from MLOD.FILE

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	DISTRIB. TYPE	Median	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	2.275	138.9955	475.6384	4.1048	112
NECK.FRONT	Lognormal	1.8975	25.192	347.498	1.8583	94
NECK.BACK	Lognormal	.352	17.0884	365.4479	.5605	100
UPPER ARMS	Other	.582	174.6754	859.3712	1.3153	81
CHEST	Other	3.0175	20.4569	259.5853	3.1796	80
BACK	Other	.71	11.6161	221.3109	1.6665	79
FOREARMS	Other	.484	4.7255	209.4022	.8135	75
THIGHS	Other	3.82	18.3668	191.5423	3.7869	62
LOWER LEGS	Other	.714	42.5789	781.3018	.9574	72
FEET	Lognormal	5.371	346.998	180.1404	19.5296	25
HANDS	Lognormal	4.65	39.0121	297.6143	4.325	71
TOTAL DERM:	39.7057	23.873	839.7056		42.0974	

95% C.I. on Mean: Dermal: [-12917.0481, 14596.4593]

Number of Records: 128
Data File: MIXER/LOADER   Subset Name: NALED1A.MLOD

APPENDIX 1B
(Mixer/Loaders)

Name: NALED1B.MLOD Subset Specifications for NALED1B.MLOD

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Mixing Procedures Equal to 1 and
With Outdoor Equal to "X" and
With Airborne Grade Equal to "A" "B"
Subset originated from MLOD.FILE

SUMMARY STATISTICS FOR CALCULATED INHALATION EXPOSURES

	DISTRIB.	NANOGRAMS PER LB AI MIXED				
	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
EXPOSURE	Other	466.6667	1686.2531	283.7279	247.4691	76

95% C.I. on Geo. Mean: [3.8108, 16070.55]

Number of Records: 83
Data File: MIXER/LOADER Subset Name: NALED1B.MLOD

APPENDIX 2A
(Aerial Flaggers)

Name: NALED2A.FLAG Subset Specifications for NALED2A.FLAG

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Dermal Grade Uncovered Equal to "A" "B"
Subset originated from FLAG.FILE

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	DISTRIB. TYPE	MICROGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	4.94	11.3028	127.5702	5.6188	18
NECK-FRONT	Lognormal	.5025	.9533	134.3334	.5146	18
NECK.BACK	Lognormal	.4895	1.4111	215.8529	.4931	18
UPPER ARMS	Other	.291	.388	36.3918	.3666	18
CHEST	Other	.355	.4438	35.7819	.4222	16
BACK	Other	.355	.4438	35.7819	.4222	16
FOREARMS	Other	.121	.4235	267.7214	.1803	18
THIGHS	Other	.382	.5491	71.7174	.4811	16
LOWER LEGS	Other	.238	.476	98.5084	.3586	18
FEET						0
HANDS	Lognormal	14.6516	14.6516	68.9979	12.7892	2
TOTAL DERM:	21.1577	22.3256	31.043		21.6467	

95% C.I. on Mean: Dermal: [-462.1881, 524.2741]

Number of Records: 18
Data File: FLAGGER Subset Name: NALED2A.FLAG

APPENDIX 2B
(Aerial Flaggers)

Name: NALED2B.FLAG Subset Specifications for NALED2B.FLAG

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Airborne Grade Equal to "A" "B"
Subset originated from FLAG.FILE

SUMMARY STATISTICS FOR CALCULATED INHALATION EXPOSURES

	DISTRIB.	NANOGRAMS PER LB AI MIXED				
	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
EXPOSURE	Normal	129.9002	135.2485	75.5819	96.1357	18

95% C.I. on Geo. Mean: [-65.1094, 335.6064]

Number of Records: 18
Data File: FLAGGER Subset Name: NALED2B.FLAG

APPENDIX 3A
(Aerial Applicators)

Name: NALED3A.APPL Subset Specifications for NALED3A.APPL

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Dermal Grade Uncovered Equal to "A" "B" and
With Application Method Equal to 5 or Equal to 6
Subset originated from APPL.FILE

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	DISTRIB. TYPE	MICROGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Other	.13	.4689	190.9362	.2178	28
NECK.FRONT	Other	.015	.0413	164.4068	.0239	28
NECK.BACK	Other	.011	.033	181.8182	.0169	28
UPPER ARMS	Other	.291	.3274	44.4411	.3117	16
CHEST	Other	.355	.355	0	.355	14
BACK	Other	.355	.355	0	.355	14
FOREARMS	Other	.121	.1452	35.124	.139	10
THIGHS	Other	.382	.382	0	.382	14
LOWER LEGS	Other	.238	.2975	54.6555	.273	16
FEET	Lognormal	.393	.4803	88.8195	.3311	12
HANDS	Lognormal	.7366	.7366	29.4461	.7205	2
TOTAL DERM:	2.9496	3.0276	3.6222		3.1259	

95% C.I. on Mean: Dermal: [-12.5748, 19.8192]
Number of Records: 28
Data File: APPLICATOR Subset Name: NALED3A.APPL

APPENDIX 3B
(Aerial Applicators)

Name: NALED3B.APPL   Subset Specifications for NALED3B.APPL

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Airborne Grade Equal to "A" "B" and
With Application Method Equal to 5 or Equal to 6
Subset originated from APPL.FILE

SUMMARY STATISTICS FOR CALCULATED INHALATION EXPOSURES

	DISTRIB. TYPE	NANOGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
EXPOSURE	Lognormal	15.2466	21.0077	117.5524	8.556	15

95% C.I. on Geo. Mean: [0.3351, 218.482]

Number of Records: 15
Data File: APPLICATOR   Subset Name: NALED3B.APPL

APPENDIX 4A
(Airblast Applicators)

Name: NALED4A.APPL Subset Specifications for NALED4A.APPL

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Dermal Grade Uncovered Equal to "A" "B" and
With Application Method Equal to 1
Subset originated from APPL.FILE

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, gloves

PATCH	DISTRIB.		MICROGRAMS PER LB AI MIXED			
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	18.85	388.3567	272.7476	26.9791	39
NECK.FRONT	Lognormal	1.695	15.0926	300.9117	2.7594	35
NECK.B.XCK	Lognormal	1.166	17.7159	240.8114	1.4981	39
UPPER ARMS	Other	.582	.7134	95.8649	.5366	31
CHEST	Other	.71	7.7463	344.1282	1.1881	39
BACK	Other	.71	4.8426	325.8312	.9606	39
FOREARMS	Lognormal	.242	.6635	163.2404	.3398	31
THIGHS	Other	.573	33.1385	335.4283	1.4449	24
LOWER LEGS	Other	.357	2.5089	249.165	.6312	24
FEET						0
HANDS	Lognormal	10.3364	13.3257	106.1618	6.2495	31
TOTAL DERM:	40.7579	35.2214	484.1041		42.5873	

95% C.I. on Mean: Dermal: (-10147.2995, 11115.5077]

Number of Records: 39
Data File: APPLICATOR Subset Name: NALED4A.APPL

APPENDIX 4B
(Airblast Applicators)

Name: NALED4B.APPL   Subset Specifications for NALED4B.APPL

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Airborne Grade Equal to "A" "B" and
With Application Method Equal to 1
Subset originated from APPL.FILE

SUMMARY STATISTICS FOR CALCULATED INHALATION EXPOSURES

	DISTRIB. TYPE	NANOGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
EXPOSURE	Lognormal	2870.717	6277.758	204.742	2682.656	27

95% C.I. on Geo. Mean: [266.8431, 26969.5845]

Number of Records: 27
Data File: APPLICATOR   Subset Name: NALED4B.APPL

APPENDIX 5A
(Groundboom Applicators)

Name: NALED5A.APPL   Subset Specifications for NALED5A.APPL

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Dermal Grade Uncovered Equal to "A" "B" and
With Application Method Equal to 2 or Equal to 3
Subset originated from APPL.FILE

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, gloves

PATCH LOCATION	DISTRIB. TYPE	Median	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	.26	1.4602	185.1938	.4689	43
NECX.FRONT	Lognormal	.06	.2283	144.5905	.0794	36
NECK.BACK	Other	.033	.1921	208.4852	.0507	39
UPPER ARMS	Other	.291	.8366	128.2572	.5337	32
CHEST	Other	.355	1.1928	125.6455	.7049	25
BACK	Other	.355	1.2354	125.0121	.7164	25
FOREARMS	Other	.121	2.4162	475.627	.2849	32
THIGHS	Lognormal	1.146	1.4065	101.4077	.9699	22
LOWER LEGS	Lognormal	.714	1.3982	180.4892	.7148	32
FEET	Lognormal	4.323	4.1629	45.8935	3.66	9
HANDS	Lognormal	3.9648	3.9648	125.2068	1.8435	2
TOTAL DERM:	8.8915	11.6228	18.494		10.0271	

95% C.I. on Mean: Dermal: [-240.8942, 277.8822]

Number of Records: 44
Data File: APPLICATOR   Subset Name: NALED5A.APPL

APPENDIX 5B
(Groundboom Applicators)

Name: NALED5B.APPL   Subset Specifications for NALED5B.APPL

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Airborne Grade Equal to "A" "B" and
With Application Method Equal to 2 or Equal to 3
Subset originated from APPL.FILE

SUMMARY STATISTICS FOR CALCULATED INHALATION EXPOSURES

	DISTRIB. TYPE	NANOGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
EXPOSURE	Lognormal	51.7178	165.4924	157.4362	50.6591	26

95% C.I. on Geo. Mean: [1.9802, 1296.002]

Number of Records: 26
Data File: APPLICATOR   Subset Name: NALED5B.APPL

APPENDIX 6A
(Backpack Applicators)

Name: NALED6A.APPL   Subset Specifications for NALED6A.APPL

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Dermal Grade Uncovered Equal to "A" "B" and
With Application Method Equal to 9
Subset originated from APPL.FILE

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Total Deposition

PATCH	DISTRIB.	MICROGRAMS PER LB AI MIXED				
LOCATION	TYPE	Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	9626.24	58902.7595	171.62	13741.5982	60
NECK.FRONT	Lognormal	2024.25	7242.2773	157.8308	2643.6795	60
NECK.BACK	Lognormal	1484.45	5311.0033	157.8308	1938.6983	60
UPPER ARMS	Lognormal	39270.45	140500.1787	157.8308	51287.3815	60
CHEST	Lognormal	47907.25	171400.5616	157.8308	62567.0806	60
BACK	Lognormal	47907.25	171400.5616	157.8308	62567.0806	60
FOREARMS	Lognormal	16328.95	58421.0365	157.8308	21325.681	60
THIGHS	Lognormal	225044.2	619291.403	145.116	236362.9993	60
LOWER LEGS	Lognormal	140210.7	385841.240	145.116	147262.8111	60
FEET	Other	227219.5	227278.45	28.787	214339.6995	20
HANDS	Other	275924.6	394292.836	80.5735	288008.9015	60
TOTAL DERM:	1102841.2	1032948.1	2239882.308		1102045.611	

95% C.I. on Mean: Dermal: [-7390270.493, 11870035.109]

Number of Records: 60
Data File: APPLICATOR   Subset Name: NALED6A.APPL

APPENDIX 6B
(Backpack Applicators)

Name: NALED6B.APPL Subset Specifications for NALED6B.APPL

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Airborne Grade Equal to "A" "B" and
With Application Method Equal to 9
Subset originated from APPL.FILE

SUMMARY STATISTICS FOR CALCULATED INHALATION EXPOSURES

	DISTRIB. TYPE	NANOGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
EXPOSURE	Other	184410.0698	264662.9895	119.4529	128768.951	40

95% C.I. on Geo. Mean: [3193.7091, 5191907.5933]

Number of Records: 40
Data File: APPLICATOR Subset Name: NALED6B.APPL

APPENDIX 7A

(Low-Pressure Hand Wand Mixer/Loader/Applicators)

Name: NALED7A.MLAP Subset Specifications for NALED7A.MLAP

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Dermal Grade Uncovered Equal to "A" "B" and
With Mixing Procedures Equal to 1 and
With Application Method Equal to 7
Subset originated from MLAP.FILE

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, no gloves

PATCH LOCATION	DISTRIB. TYPE	Median	MICROGRAMS PER LB AI MIXED Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	24.375	124.293	137.9493	47.2773	10
NECK.FRONT	Lognormal	6.0975	453.432	311.0744	8.6612	10
NECK.BACK	Lognormal	1.144	330.0869	313.6188	4.0327	10
UPPER ARMS	Lognormal	15.132	111.8313	232.934	32.6211	10
CHEST	Other	18.46	235.1875	185.929	48.9756	10
BACK	Other	18.46	163.797	202.4421	41.5723	10
FOREARMS	Other	6.292	40.9585	267.6492	9.412	10
THIGHS	Other	19.864	37.9878	115.1859	27.6737	9
LOWER LEGS	Lognormal	12.376	66.9309	164.3135	30.0241	9
FEET						0
HANDS						0
TOTAL DERM:	185.6924	122.2005	1564.5049		250.25	

95% C.I. on Mean: Dermal: [-35036.7278, 38165.7376]

Number of Records: 10
Data File: MIXER/LOADER/APPLICATOR Subset Name: NALED7A.MLAP

APPENDIX 7B

(Low-Pressure Hand Wand Mixer/Loader/Applicators)

Name: NALED7B.MLAP Subset Specifications for NALED7B.MLAP

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Airborne Grade Equal to "A" "B" and
With Mixing Procedures Equal to 1 and
With Application Method Equal to 7
Subset originated from MLAP.FILE

SUMMARY STATISTICS FOR CALCULATED INHALATION EXPOSURES

	DISTRIB. TYPE	NANOGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
EXPOSURE	Other	14583.3333	19148.8095	75.3953	16805.3069	10

95% C.I. on Geo. Mean: [6976.1648, 40483.3237]

Number of Records: 10
Data File: MIXER/LOADER/APPLICATOR Subset Name: NALED7B.MLAP

APPENDIX 8A
(Backpack Mixer/Loader/Applicators)

Name: NALED8A.MLAP   Subset Specifications for NALED8A.MLAP

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Dermal Grade Uncovered Equal to "A" "B" and
With Mixing Procedures Equal to 1 and
With Application Method Equal to 9
Subset originated from MLAP.FILE

SUMMARY STATISTICS FOR CALCULATED DERMAL EXPOSURES

SCENARIO: Long pants, long sleeves, no gloves

PATCH LOCATION	DISTRIB. TYPE	MICROGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
HEAD (ALL)	Lognormal	70.46	345.2564	194.899	91.4483	11
NECK.FRONT	Lognormal	43.38	178.6391	155.1078	38.2719	11
NECK.BACK	Lognormal	617.441	1163.209	108.1731	611.9794	11
UPPER ARMS	Lognormal	104.469	10116.4827	239.4633	257.2654	11
CHEST	Normal	18.46	275.4477	170.903	65.7564	11
BACK	Lognormal	477.83	8918.1809	167.9854	1044.0635	11
FOREARMS	Lognormal	6.292	153.593	184.2219	30.0425	11
THIGHS	Lognormal	19.864	597.2782	282.8189	49.147	9
LOWER LEGS	Lognormal	32.13	425.8878	230.6324	64.6874	9
FEET						0
HANDS						0
TOTAL DERM:	2462.3531	1390.326	22173.9748		2252.6618	

95% C.I. on Mean: Dermal: (-512436.8583, 556784.8079]

Number of Records: 11
Data File: MIXER/LOADER/APPLICATOR   Subset Name.: NALED8A.MLAP

APPENDIX 8B
(Backpack Mixer/Loader/Applicators)

Name: NALED8B.MLAP Subset Specifications for NALED8B.MLAP

With Liquid Type Equal to 1 or Equal to 2 or Equal to 3 or Equal to 4 or Equal to 5 and
With Airborne Grade Equal to "A" "B" and
With Mixing Procedures Equal to 1 and
With Application Method Equal to 9
Subset originated from MLAP.FILE

SUMMARY STATISTICS FOR CALCULATED INHALATION EXPOSURES

	DISTRIB. TYPE	NANOGRAMS PER LB AI MIXED Median	Mean	Coef of Var	Geo. Mean	Obs.
EXPOSURE	Other	14583.3333	14699.0509	4.8415	14683.9317	11

95% C.I. on Geo. Mean: [13408.489, 16080.697]

Number of Records: 11
Data File: MIXER/LOADER/APPLICATOR Subset Name: NALED8B.MLAP

XIV. ADDENDA

Addendum 1: Request for Calculation of Dermal Doses in Units of μg/cm^2.

Addendum 2: Dermal Doses (μg/cm^2) Calculated for Acute Localized Skin Effects of Naled, from Handler Exposure.

Addendum 3: Dermal Doses (μg/cm^2) Calculated for Acute Localized Skin Effects of Naled, from Reentry Exposure.

Addendum 4: Dermal Doses (μg/cm^2) Calculated for Subacute Localized Skin Effects of Naled, from Handler Exposure.

Addendum 5: Dermal Doses (μg/cm^2) Calculated for Subacute Localized Skin Effects of Naled, from Reentry Exposure.

Addendum 6: Example Calculation of Dermal Dose and Assumptions Used.

Addendum 1. Request for Calculation of Dermal Doses in Units of $\mu g/cm^2$.

dpr **Department of Pesticide Regulation**

Paul E. Helliker
Director

MEMORANDUM

Gray Davis
Governor
Winston H. Hickox
Secretary, California Environmental Protection Agency

TO: Charles Andrews
Chief
Worker Health and Safety Branch

VIA: Keith Pfeifer
Senior Toxicologist
Medical Toxicology Branch

FROM: Lori Lim
Staff Toxicologist
Medical Toxicology Branch

DATE: June 22, 2000

SUBJECT: Risk Characterization of Naled Effects on the Skin

In the Risk Characterization Document for Naled (November 11, 1999), we evaluated the dermal toxicity only for seasonal exposure since there was systemic toxicity noted in a 21-day dermal toxicity study in rats. Since the completion of the RCD, we have determined that additional assessment was necessary to address the local effects on the skin observed 1 day (erythema) as well as 21-days (acute inflammation and acute ulcerative inflammation) after application of naled on the skin. We also have determined that the exposure for the skin effects should be expressed in terms of amount of naled/skin surface area instead of amount naled/body weight. The current exposure levels in the Exposure Assessment are expressed in terms of body weight unit. Therefore, we are requesting addition exposure levels in form of acute and subchronic exposure levels (in terms of surface area) for the risk characterization of naled.

cc. J. Gee
G. Patterson

830 K Street • Sacramento, California 95814-3510 • www.cdpr.ca.gov
A Department of the California Environmental Protection Agency

Addendum 2. Dermal Doses ($\mu g/cm^2$) Calculated for Acute Localized Skin Effects of Naled, from Handler Exposure.

Work Group	**HEAD**	**NECK**	**U. ARMS**	**CHEST**	**BACK**	**F. ARMS**	**THIGHS**	**L. LEGS**	**FEET**	**HANDS**	**WHOLE**	**DOSAGE**
PHED Surface Area, cm^2	*1300.00*	*260.00*	*2910.00*	*3550.00*	*3550.00*	*1210.00*	*3820.00*	*2380.00*	*1310.00*	*820.00*	*21110.00*	
Mixer/Loaders	139.00	42.30	174.70	20.50	11.60	4.70	18.40	42.60	347.00	39.00	839.70	
Dose (ground)	**0.56**	**0.86**	**0.32**	**0.03**	**0.02**	**0.02**	**0.03**	**0.09**	**1.39**	**0.25**	**0.21**	22.10
Dose (aerial)	**3.38**	**5.14**	**1.90**	**0.18**	**0.10**	**0.12**	**0.15**	**0.57**	**8.37**	**1.50**	**1.26**	132.70
Aerial Flaggers	11.30	2.40	0.40	0.40	0.40	0.40	0.55	0.50		14.70	31.00	
Dose	**5.80**	**6.16**	**0.09**	**0.08**	**0.08**	**0.22**	**0.10**	**0.14**		**11.97**	**0.98**	103.50
Aerial Applicators	0.50	0.07	0.33	0.36	0.36	0.15	0.38	0.30	0.48	0.74	3.60	
Dose (agricultural)	**0.18**	**0.13**	**0.05**	**0.05**	**0.05**	**0.06**	**0.05**	**0.06**	**0.17**	**0.42**	**0.08**	8.47
Dose (mosquito)	**1.28**	**0.90**	**0.38**	**0.34**	**0.34**	**0.41**	**0.33**	**0.42**	**1.22**	**3.01**	**0.57**	60.00
Airblast Applicators	388.40	32.80	0.70	7.70	4.80	0.70	33.10	2.50		13.30	484.10	
Dose	**8.41**	**3.55**	**0.01**	**0.06**	**0.04**	**0.02**	**0.24**	**0.03**		**0.46**	**0.65**	68.10
Ground Applicators	1.50	0.40	0.80	1.20	1.20	2.40	1.40	1.40	4.20	4.00	18.50	
Dose	**0.11**	**0.15**	**0.03**	**0.03**	**0.03**	**0.19**	**0.04**	**0.06**	**0.31**	**0.47**	**0.08**	8.90
Backpack Applicators	58.90	12.55	140.50	171.40	171.40	58.42	619.29	385.84	227.28	394.29	2239.88	
Dose	**3.65**	**3.89**	**3.89**	**3.89**	**3.89**	**3.89**	**13.08**	**13.08**	**13.99**	**38.78**	**8.56**	903.30
M/L/A Handwand	124.40	783.50	111.80	235.20	163.80	41.00	38.00	66.90			1564.50	
Dose (commercial)	**0.03**	**0.89**	**0.01**	**0.02**	**0.01**	**0.01**	**0.003**	**0.008**			**0.02**	2.30
Dose (homeowner)	**0.018**	**0.58**	**0.007**	**0.013**	**0.009**	**0.006**	**0.0019**	**0.005**			**0.014**	1.50
M/L/A Backpack	345.30	1341.80	10116.50	275.40	8918.20	153.60	597.30	425.90			22174.00	
Dose (commercial)	**0.08**	**1.64**	**1.11**	**0.02**	**0.80**	**0.04**	**0.05**	**0.06**			**0.33**	35.30
Dose (homeowner)	**0.12**	**2.43**	**1.63**	**0.036**	**1.18**	**0.06**	**0.07**	**0.08**			**0.49**	52.10

1. *See* Addendum 6 (Example Calculation of Dermal Dose and Assumptions Used) for algorithm and assumptions used; example: dose (head for ground mixer/loaders) = [(139.0 μg/lb)/(839.7 μg/lb) x (22.1 μg/kg/day) x (35% dermal absorption)$^{-1}$ x (70 kg)]/(1,300 cm^2) = 0.56 $\mu g/cm^2$.
2. Right above the calculated dermal dose (in bold) is the dermal exposure rate (μg/lb active ingredient handled).
3. The dosage in the last column is in μg/kg body weight/day (as in Tables 8 and 9), based on a dermal absorption of 35% where applicable.

Addendum 3. Dermal Doses ($\mu g/cm^2$) Calculated for Acute Localized Skin Effects of Naled, from Reentry Exposure.

Dermal Dose (µg/cm2) Calculated for ACUTE Localized Skin Effects of Naled, *Reentry Exposure*

Work Group	HEAD	NECK	U. ARMS	CHEST	BACK	F. ARMS	THIGHS	L. LEGS	FEET	HANDS	WHOLE	DOSAGE
WH&S Surface Area, cm^2						*1200.00*				*800.00*	*18000.00*	
Grape Girdlers												
Dose											**0.07**	6.30
Grape Harvesters												
Dose										**0.05**	**0.0067**	0.60
Cotton Scouts												
Dose											**0.021**	1.90
Vegetables Harvesters												
Dose										**0.85**	**0.111**	10.00
Greenhouse Harvesters												
Dose										**19.05**	**2.49**	224.10
Pet Collars												
Dose (veterinarian)										**4.45**		44.50
Dose (homeowner)										**22.23**		222.30
Residents (non-user)												
Dose (also children)											**0.22**	20.00

1. *See* Addendum 6 (Example Calculation of Dermal Dose and Assumptions Used) for algorithm and assumptions used; example: dose (whole body for non-user residents) = [(100% of total exposure/dose) x (20.0 µg/kg/day) x (35% dermal absorption)$^{-1}$ x (70 kg)]/(18,000 cm^2) = 0.22 $\mu g/cm^2$.
2. Right above the calculated dermal dose in bold is the dermal exposure rate (µg/lb active ingredient handled).
3. The dosage in the last column is in µg/kg body weight/day (as in Tables 4, 5, and 9), based on a dermal absorption of 35% where applicable.
4. The hand exposures above included forearms and were assumed to contribute to 85% of the total dermal exposure due to task involved.
5. Children may be included in the non-user residents because the body weight to body surface ratio for adults still exceeds that for children.
6. The surface areas used here were based on (round-off) default values adopted by WH&S, taking into account that female workers with a relatively smaller body surface are frequently involved in this type of reentry activities.

Addendum 4. Dermal Doses ($\mu g/cm^2$) Calculated for Subacute Localized Skin Effects of Naled, from Handler Exposure.

Work Group	HEAD	NECK	U. ARMS	CHEST	BACK	F. ARMS	THIGHS	L. LEGS	FEET	HANDS	WHOLE	DOSAGE
PHED Surface Area, cm^2	*1300.00*	*260.00*	*2910.00*	*3550.00*	*3550.00*	*1210.00*	*3820.00*	*2380.00*	*1310.00*	*820.00*	*21110.00*	
Mixer/Loaders	139.00	42.30	174.70	20.50	11.60	4.70	18.40	42.60	347.00	39.00	839.70	
Dose (ground)	**0.32**	**0.49**	**0.18**	**0.02**	**0.01**	**0.01**	**0.01**	**0.05**	**0.80**	**0.14**	**0.12**	12.70
Dose (aerial)	**1.93**	**2.94**	**1.08**	**0.10**	**0.06**	**0.07**	**0.09**	**0.32**	**4.78**	**0.86**	**0.72**	75.80
Aerial Flaggers	11.30	2.40	0.40	0.40	0.40	0.40	0.55	0.50		14.70	31.00	
Dose	**3.32**	**3.53**	**0.05**	**0.04**	**0.04**	**0.13**	**0.05**	**0.08**		**6.85**	**0.56**	59.20
Aerial Applicators	0.50	0.07	0.33	0.36	0.36	0.15	0.38	0.30	0.48	0.74	3.60	
Dose (agricultural)	**0.10**	**0.07**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.10**	**0.24**	**0.05**	4.80
Dose (mosquito)	**0.73**	**0.51**	**0.22**	**0.19**	**0.19**	**0.24**	**0.19**	**0.24**	**0.70**	**1.71**	**0.32**	34.20
Airblast Applicators	388.40	32.80	0.70	7.70	4.80	0.70	33.10	2.50		13.30	484.10	
Dose	**4.79**	**2.02**	**0.004**	**0.03**	**0.02**	**0.01**	**0.14**	**0.02**		**0.26**	**0.37**	38.80
Ground Applicators	1.50	0.40	0.80	1.20	1.20	2.40	1.40	1.40	4.20	4.00	18.50	
Dose	**0.06**	**0.08**	**0.02**	**0.02**	**0.02**	**0.11**	**0.02**	**0.03**	**0.18**	**0.27**	**0.05**	5.10
Backpack Applicators	58.90	12.55	140.50	171.40	171.40	58.42	619.29	385.84	227.28	394.29	2239.88	
Dose	**2.09**	**2.22**	**2.22**	**2.22**	**2.22**	**2.22**	**7.47**	**7.47**	**8.00**	**22.16**	**4.89**	516.10
M/L/A Handwand	124.40	783.50	111.80	235.20	163.80	41.00	38.00	66.90			1564.50	
Dose (commercial)	**0.02**	**0.51**	**0.01**	**0.01**	**0.01**	**0.01**	**0.002**	**0.005**			**0.01**	1.32
Dose (homeowner)	**0.002**	**0.06**	**0.001**	**0.001**	**0.001**	**0.001**	**0.0002**	**0.001**			**0.001**	0.15
M/L/A Backpack	345.30	1341.80	10116.50	275.40	8918.20	153.60	597.30	425.90			22174.00	
Dose (commercial)	**0.05**	**0.94**	**0.63**	**0.01**	**0.46**	**0.02**	**0.03**	**0.03**			**0.19**	20.20
Dose (homeowner)	**0.01**	**0.24**	**0.16**	**0.004**	**0.12**	**0.01**	**0.01**	**0.01**			**0.05**	5.22

1. *See* Addendum 6 (Example Calculation of Dermal Dose and Assumptions Used) for algorithm and assumptions used; example: dose (chest for aerial flaggers) = [(0.4 $\mu g/lb$)/(31.0 $\mu g/lb$) x (59.2 $\mu g/kg/day$) x (35% dermal absorption)$^{-1}$ x (70 kg)]/(3,550 cm^2) = 0.04 $\mu g/cm^2$.
2. Right above the calculated dermal dose (in bold) is the dermal exposure rate ($\mu g/lb$ active ingredient handled).
3. The dosage in the last column is in $\mu g/kg$ body weight/day (as in Tables 8 and 9), based on a dermal absorption of 35% where applicable.

Addendum 5. Dermal Doses ($\mu g/cm^2$) Calculated for Subacute Localized Skin Effects of Naled, from Reentry Exposure.

Work Group	**HEAD**	**NECK**	**U. ARMS**	**CHEST**	**BACK**	**F. ARMS**	**THIGHS**	**L. LEGS**	**FEET**	**HANDS**	**WHOLE**	**DOSAGE**
WH&S Surface Area, cm^2						*1200.00*				*800.00*	*18000.00*	
Grape Girdlers												
Dose											**0.03**	2.71
Grape Harvesters												
Dose										**0.02**	**0.0030**	0.27
Cotton Scouts												
Dose											**0.009**	0.81
Vegetables Harvesters												
Dose										**0.37**	**0.048**	4.30
Greenhouse Harvesters												
Dose										**8.19**	**1.07**	96.32
Pet Collars												
Dose (veterinarian)										**2.54**		25.40
Dose (homeowner)										**2.22**		22.23
Residents (non-user)												
Dose (also children)											**0.04**	4.00

1. *See* Addendum 6 (Example Calculation of Dermal Dose and Assumptions Used) for algorithm and assumptions used; example: dose (hands for grape harvesters) = [(85% of total exposure/dose, footnote 4) x (0.27 $\mu g/kg/day$) x (35% dermal absorption)$^{-1}$ x (70 kg)]/(2,000 cm^2) = 0.02 $\mu g/cm^2$.
2. Right above the calculated dermal dose in bold is the dermal exposure rate ($\mu g/lb$ active ingredient handled).
3. The dosage in the last column is in $\mu g/kg$ body weight/day (as in Tables 4, 5, and 9), based on a dermal absorption of 35% where applicable.
4. The hand exposures above included forearms and were assumed to contribute to 85% of the total dermal exposure due to task involved.
5. Children may be included in the non-user residents because the body weight to body surface ratio for adults still exceeds that for children.
6. The surface areas used here were based on (round-off) default values adopted by WH&S, taking into account that female workers with a relatively smaller body surface are frequently involved in this type of reentry activities.

Addendum 6. Example Calculation of Dermal Dose and Assumptions Used.

In Addenda 2 and 4, where handler exposures were considered, the surface areas from PHED were used for the individual body regions because almost all of the dermal exposure rates and dosages listed in Tables 8 and 9 were also from PHED. On the other hand, the surface areas used in Addenda 3 and 5, where reentry exposures were considered, were based on default values adopted by WH&S, taking into account that female workers with a relatively smaller body surface are frequently involved in this type of reentry activities. Unabsorbed dermal doses were calculated for all critical body parts because *localized* skin effects were of concern and because different body regions typically receive different level of exposure depending on the task or activity involved.

The PHED database provides the dermal exposure rates (e.g., µg dermal residues per pound of active ingredient handled) for the individual body regions. To facilitate discussion, these dermal exposure rates for the individual body regions, along with their surface areas, are reproduced in Addenda 2 and 4. To back calculate the dermal dose in µg/cm^2 from the absorbed dosages listed in Tables 5, 8, and 9, the following algorithm was used.

Dose (body region) = [(*portion* of total dermal exposure attributed to the body region in question) x ((absorbed dosage in µg/kg body weight/day) x (body weight used) x (dermal absorption used)$^{-1}$]/(surface area of body region).

As an example, the dermal dose of the head region for ground mixer/loaders in Addendum 4 was calculated as follows.

Dose (head) = [(139.0 µg/lb handled for head, as listed in Addendum 4)/(839.7 µg/lb handled for whole body, as listed in Addendum 4 and Appendix 1A) x (12.7 µg/kg/day, as listed in Table 8) x (35% dermal absorption used)$^{-1}$ x (70 kg)]/(1,300 cm^2) = 0.32 µg/cm^2.

Note that several adjustment factors should have been included in the above calculation, but partly for simplicity were omitted because their effects on the calculation collectively (and roughly) cancelled one another out. Another reason for not considering these adjustment factors separately is that they cannot be quantified easily. These adjustment factors included:

1. Eight (8) work hours were assumed compared to the 6 test hours per day in the rat dermal toxicity study, yielding an apparent excess of 33% worker exposure;

2. Half of the 8 hourly worker exposures would be acquired during the second work shift and hence would last less than 4 hours long;

3. Workers might not take a shower or bath to wash the residues off their skin until a couple of hours after work, thus prolonging the daily exposure duration;

4. As discussed in the Exposure Appraisal section (under Exposure to DDVP), approximately 10 to 20% of the naled on human skin would evaporate off (primarily as DDVP); and

5. Occlusion of naled on the rat skin in the dermal toxicity study increased irritation.